Chemical Category: POLYCHLORINATED DIBENZO-*p*-DIOXINS

Chemical Name (Common Synonyms): **CASRN:** 35822-46-9
1,2,3,4,6,7,8-HEPTACHLORO DIBENZO-*p*-DIOXIN

Chemical Characteristics

Solubility in Water: No data [1], 2.4 mg/L [2]

Half-Life: No data [2,3]

Log K_{ow}: No data [4], 8.00 [2]

Log K_{oc}: 7.86 L/kg organic carbon

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [5]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,4,6,7,8-heptaCDD in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The log BMF from alewife to herring gulls in Lake Ontario was 1.51 for 2,3,7,8-TCDD [7]. Log BMFs of 1.18 to 1.70 were determined for mink fed 1,2,3,4,6,7,8-Hepta CDD in the diet [18].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [8]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1.0	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: In one study, the BSAF for carp collected from a reservoir in central Wisconsin was 0.0048. In a laboratory study, log BCFs for fathead minnow, rainbow trout, and goldfish exposed to 1,2,3,4,6,7,8-HeptaCDD were 2.71, 3.15, and 4.28, respectively.

Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,4,6,7,8-heptaCDD. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotransformation by forage fish. BMFs greater than 1.0 may exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [8].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [6]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical

stability with increasing chlorination [9,6]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [6].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [9]. Toxicity equivalency factors (TEFs) have been developed by EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [10]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [10].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [10]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [8]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [6]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [8]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [11].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario were examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A log BCF value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larvae appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,6,7,8-HeptaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Salmonids							0.0031	[20]	F
Oncorhynchus mukiss (Salmo gairderni), Rainbow trout		Exposure water 11-55 ng/L			3.15 ± 2.35			[16]	L
Oncorhynchus mukiss (Salmo gairderni), Rainbow trout			0.000035 mg/kg (liver)[4]	Biochemical, LOED				[19]	L; significant increase in liver ethoxyresorufin O-deethylase (EROD)
Cyprinus carpio, Carp	2,190 pg/g[5]		27 pg/g[5]				0.0048	[13]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,6,7,8-HeptaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Carassius auratus, Goldfish			1.91/2.2 ng/g[5] (whole body)		4.28			[15]	L; fish were exposed for 120 hr; exposure water contained fly ash extract; concentrations were measured in water, but data were not presented
Pimephales promelas, Fathead minnow		Exposure water 8-39 ng/L			2.71 ± 2.03			[16]	L
Platycephalus caerulopunctatus and *Platycephalus bassensis,* Flathead	0.356 pg/g, dw		558 pg/kg					[14]	F; unimpacted coastal site; surface sediment composite; most other dioxin congeners were below detection.
Sillago bassensis, School whiting	0.356 pg/g, dw		375 pg/kg						
Wildlife									
Falco peregrinus, Peregrine falcon			0.7 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[17]	F; Kola Peninsula, Russia

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,6,7,8-HeptaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mustela vison, Mink	Diet: 5 pg/g[5]		115 pg/g[5] (liver)	NOAEL		log BMF = 1.18		[18]	L; BMF = lipid-normalized concentration in the liver divided by the lipid-normalized dietary concentration
	7 pg/g[5]		330 pg/g[5] (liver)	LOAEL; reduced kit body weights followed by reduced survival		log BMF = 1.70			
	6 pg/g[5]		290 pg/g[5] (liver)	Reduced kit body weights followed by reduced survival		log BMF = 1.69			
	13 pg/g[5]		380 pg/g[5] (liver)	Significant decrease in number of live kits whelped per female		log BMF = 1.66			

[1] Concentration units based on wet weight unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZO-*p*-DIOXINS

Chemical Name (Common Synonyms): **CASRN:** 39227-28-6
1,2,3,4,7,8-HEXACHLORODIBENZO-*p*-DIOXIN

Chemical Characteristics

Solubility in Water: No data [1], 8.25×10^{-6} mg/L [1,2]

Half-Life: No data [2,3]

Log K_{ow}: No data [4], 7.70 [2]

Log K_{oc}: 7.57 L/kg organic carbon

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: —

Oral Slope Factor (Reference): No data [5]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,4,7,8-hexaCDD in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [7]. A log BMF of 0.97 was reported for mink exposed to 1,2,3,4,7,8-hexaCDD in the diet. [14].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

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For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: In a laboratory study, log BCFs for rainbow trout and fathead minnow exposed to 1,2,3,4,7,8-HexaCDD were 3.73 and 4.00, respectively.

Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,4,7,8-hexaCDD. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotransformation by forage fish. BMFs greater than 1.0 may exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [8].

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Other HeptaCDDs	0.00001
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PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario were examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A log BCF value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larvae appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Oncorhynchus mukiss (Salmo gairderni), Rainbow trout		Exposure water 10-47 ng/L			3.73			[11]	L
Oncorhynchus mukiss, Rainbow trout			0.0000395 mg/kg (liver)[4]	Biochemical, LOED				[15]	L; significant increase in liver ethoxyresorufin O-deethylase (EROD)
*Pimephales promela*s, Fathead minnow		Exposure water 10-47 ng/L			4.00			[11]	L
Wildlife									
Falco peregrinus, Peregrine falcon			3.3 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[13]	F; Kola Peninsula, Russia

Summary of Biological Effects Tissue Concentrations for 1,2,3,4,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mustela vison, Mink	Diet: 2 pg/g[5]		6 pg/g[5] (liver)	LOAEL; reduced kit body weights followed by reduced survival		No BMF reported		[14]	L; BMF = biomagnification factor = v_l/v_d v_l = lipid-normalized tissue concentration, v_d = lipid-normalized dietary concentration.
	1 pg/g[5]		77 pg/g[5] (liver)	Reduced kit body weights followed by reduced survival		No BMF reported			
	3 pg/g[5]		15 pg/g[5] (liver)	Significant decrease in number of live kits whelped per female		Log BMF = 0.97			

[1] Concentration units based on wet weight unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZO-*p*-DIOXINS

Chemical Name (Common Synonyms): **CASRN:** 57653-85-7
1,2,3,6,7,8-HEXACHLORODIBENZO-*p*-DIOXIN

Chemical Characteristics

Solubility in Water: No data [1,2]

Half-Life: No data [2,3]

Log K_{ow}: No data [2,4]

Log K_{oc}: —

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: Hepatic tumors in mice and rats

Oral Slope Factor: $6.2 \times 10^{+3}$ per (mg/kg)/day [5]

Carcinogenic Classification: B2 [5]

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,6,7,8-hexaCDD in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [7]. Log BMFs of 1.42 and 1.43 were reported for mink exposed to 1,2,3,6,7,8-hexaCDD in the diet [18].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [8]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1.0	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: In one study, the BSAF for carp collected from a reservoir in central Wisconsin was 0.035. The log BCF for goldfish during a laboratory exposure for 120 hours was 4.61.

Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,6,7,8-hexaCDD. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotansformation by forage fish. BMFs greater than 1.0 may exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates[8].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [6]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical

stability with increasing chlorination [9,6]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [6].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8 TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [9]. Toxicity equivalency factors (TEFs) have been developed by EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [10]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [10].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [10]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [6]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [8]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [11].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario were examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A log value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larvae appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 1,2,3,6,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Carassius auratus, Goldfish			0.79 ng/g[4] (whole body)		4.61			[14]	L; fish were exposed for 120 hr; exposure water contained fly ash extract; concentrations were measured in water, but data were not presented
Cyprinus carpio, Carp	180 pg/g[4]		16 pg/g[4]				0.035	[13]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon
Salmonids							0.0073	[19]	F

Summary of Biological Effects Tissue Concentrations for 1,2,3,6,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Falco peregrinus, Peregrine falcon			7.2 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[17]	F; Kola Peninsula, Russia
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: ~9,000 ng/kg lipid weight basis (yolk sac) Reference site: ~500 ng/kg lipid weight basis (yolk sac)	A hepatic cytochrome P4501A cross-reactive protein (CYP1A) was induced nearly 6-fold in chicks from Powell River site compared to the reference ($p < 0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[15]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the lab; ~ indicates value was taken from a figure

Summary of Biological Effects Tissue Concentrations for 1,2,3,6,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ardea herodias, Great blue heron chicks			Nicomekl site: 10±3.4 ng/kg (egg) (n=11)					[16]	L; eggs were collected from three British Columbia colonies with different levels of contamination and incubated in the laboratory
			Vancouver site: 89±45.4 ng/kg (egg) (n=12)	Depression of growth compared to Nicomekl site. Presence of edema.					
			Crofton site: 430±105.9 ng/kg (egg) (n=6)	Depression of growth compared to Nicomekl site. Presence of edema.					

Summary of Biological Effects Tissue Concentrations for 1,2,3,6,7,8-HexaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mustela vison, Mink	Diet: 1 pg/g[4]		54 pg/g[4] (liver)	LOAEL; reduced kit body weights followed by reduced survival		No BMF reported		[18]	L; BMF = biomagnification factor = v_l/v_d, v_l = lipid-normalized tissue concentration, v_d = lipid-normalized dietary concentration.
	3 pg/g[4]		77 pg/g[4] (liver)	Reduced kit body weights followed by reduced survival		log BMF = 1.42			
	6 pg/g[4]		130 pg/g[4] (liver)	Significant decrease in number of live kits whelped per female		log BMF = 1.53			

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZO-*p*-DIOXINS

Chemical Name (Common Synonyms): **CASRN:** 40321-76-4
1,2,3,7,8-PENTACHLORODIBENOZ-*p*-DIOXIN

Chemical Characteristics

Solubility in Water: No data [1,3]

Half-Life: No data [2,3]

Log K_{ow}: No data [3,4]

Log K_{oc}: —

Human Health

Oral RfD: No data [5]

Confidence: —

Critical Effect: —

Oral Slope Factor: No data [5]

Carcinogenic Classification: —

Wildlife

Partitioning Factors: Partitioning factors for 1,2,3,7,8-pentaCDD in wildlife were not found in the studies reviewed.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife; no information was available for 1,2,3,7,8-pentaCDD, specifically. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [6]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the log biomagnification factor (BMF) can equal 0.48. The log BMF from alewife to herring gulls in Lake Ontario was 1.51 for 2,3,7,8-TCDD [7].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [8]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1.0	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: Partitioning factors for 1,2,3,7,8-pentaCDF in aquatic organisms were not found in the studies reviewed.
Food Chain Multipliers: No specific food chain multipliers were identified for 1,2,3,7,8-pentaCDD. Food chain multiplier information was only available for 2,3,7,8-TCDD. Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotransformation by forage fish. BMFs greater than 1.0 might exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates[8].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [6]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [6,9]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [6].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-TCDD, one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [9]. Toxicity equivalency factors (TEFs) have been developed by the U.S. EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [10]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [10].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [10]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [8]. Congener-specific analyses have shown that the 2,3,7,8-substituted PCDDs and PCDFs were the major compounds present in most sample extracts [6]. Results

from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [8]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [11].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [8]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario were examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [8]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual log BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A log BCF value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larvae appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.78 [11].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [12]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [11].

Summary of Biological Effects Tissue Concentrations for 1,2,3,7,8-PentaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Carassius auratus, Goldfish			1.59/2.61 ng/g[4] (whole body)		16,982			[14]	L; fish were exposed for 120 hr; exposure water contained fly ash extract; concentrations were measured in water, but data were not presented
Cyprinus carpio, Carp	31 pg/g[4]		4.8 pg/g[4]		0.06			[13]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon
Salmonids							0.054	[18]	F
Wildlife									
Falco peregrinus, Peregrine falcon			11 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[17]	F; Kola Peninsula, Russia

Summary of Biological Effects Tissue Concentrations for 1,2,3,7,8-PentaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: ~2,800 ng/kg lipid weight basis (yolk sac) Reference site: ~500 ng/kg lipid weight basis (yolk sac)	A hepatic cytochrome P4501A cross-reactive protein (CYP1A) was induced nearly six-fold in chicks from Powell River site compared to the reference ($p < 0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[15]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the lab; ~ indicates value was taken from a figure.

Summary of Biological Effects Tissue Concentrations for 1,2,3,7,8-PentaCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ardea herodias, Great blue heron chicks			Nicomekl site: 6±2.2 ng/kg (egg) (n = 11)					[16]	L; eggs were collected from three British Columbia colonies with different levels of contamination and incubated in the laboratory
			Vancouver site: 57±25.8 ng/kg (egg) (n = 12)	Depression of growth compared to Nicomekl site. Presence of edema.					
			Crofton site: 263±69.9 ng/kg (egg) (n = 6)	Depression of growth compared to Nicomekl site. Presence of edema.					

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: POLYCHLORINATED DIBENZO-*p*-DIOXINS

Chemical Name (Common Synonyms): **CASRN:** 1746-01-6
2,3,7,8-TETRACHLORODIBENZO-*p*-DIOXIN

Chemical Characteristics

Solubility in Water: 19.3 ng/L [1]

Half-Life: 1.1.15 - 1.62 years based on soil die-away test and lake water and sediment die-away test [2]

Log K_{ow}: 6.53 [3]

Log K_{oc}: 6.42 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: —

Oral Slope Factor: 1.5 x 10^{+5} per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for 2,3,7,8-TCDD in wildlife were not found in the literature.

Food Chain Multipliers: Limited information was found reporting on specific biomagnification factors of PCDDs and PCDFs through terrestrial wildlife. Due to the toxicity, high K_{ow} values, and highly persistent nature of the PCDDs and PCDFs, they possess a high potential to bioaccumulate and biomagnify through the food web. PCDDs and PCDFs have been identified in fish and wildlife throughout the global aquatic and marine environments [5]. Studies conducted in Lake Ontario indicated that biomagnification of 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD) appears to be significant between fish and fish-eating birds but not between fish and their food. When calculated for older predaceous fish such as lake-trout-eating young smelt, the biomagnification factor (BMF) can equal 3. The BMF from alewife to herring gulls in Lake Ontario was 32 for 2,3,7,8-TCDD [6].

EPA has developed risk-based concentrations of 2,3,7,8-TCDD in different media that present low and high risk to fish, mammalian, and avian wildlife. These concentrations were developed based on toxic effects of 2,3,7,8-TCDD and its propensity to bioaccumulate in fish, mammals, and birds.

Environmental Concentrations Associated With 2,3,7,8-TCDD Risk to Aquatic Life and Associated Wildlife [7]

Organism	Fish Concentration (pg/g)	Sediment Concentration (pg/g dry wt.)	Water Concentration (pg/L)	
			POC=0.2	POC=1.0
Low Risk				
Fish	50	60	0.6	3.1
Mammalian Wildlife	0.7	2.5	0.008	0.04
Avian Wildlife	6	21	0.07	0.35
High Risk to Sensitive Species				
Fish	80	100	1.0	5
Mammalian Wildlife	7	25	0.08	0.4
Avian Wildlife	60	210	0.7	3.5

Note: POC - Particulate organic carbon
Fish lipid of 8% and sediment organic carbon of 3% assumed where needed.
For risk to fish, BSAF of 0.3 used; for risk to wildlife, BSAF of 0.1 used.
Low risk concentrations are derived from no-effects thresholds for reproductive effects (mortality in embryos and young) in sensitive species.
High risk concentrations are derived from TCDD doses expected to cause 50 to 100% mortality in embryos and young of sensitive species.

Aquatic Organisms

Partitioning Factors: Steady-state BSAFs for invertebrates exposed to 2,3,7,8-TCDD in the laboratory ranged from about 0.5 to 0.9 [8]. The BSAF for carp collected from a reservoir in central Wisconsin was 0.27 [9].

Food Chain Multipliers: Biomagnification of 2,3,7,8-TCDD does not appear to be significant between fish and their prey. Limited data for the base of the Lake Ontario lake trout food chain indicated little or no biomagnification between zooplankton and forage fish. BMFs based on fish consuming invertebrate species are probably close to 1.0 because of the 2,3,7,8-TCDD biotansformation by forage fish. BMFs greater than 1.0 may exist between some zooplankton species and their prey due to the lack of 2,3,7,8-TCDD biotransformation in invertebrates [7].

Toxicity/Bioaccumulation Assessment Profile

The polychlorinated dibenzo-*p*-dioxins (PCDDs) and polychlorinated dibenzofurans (PCDFs) each consist of 75 isomers that differ in the number and position of attached chlorine atoms. The PCDDs and PCDFs are polyhalogenated aromatic compounds and exhibit several properties common to this group of compounds. These compounds tend to be highly lipophilic and the degree of lipophilicity is increased with increasing ring chlorination [5]. In general, the PCDDs and PCDFs exhibit relative inertness to acids, bases, oxidation, reduction, and heat, increasing in environmental persistence and chemical stability with increasing chlorination [10,5]. Because of their lipophilic nature, the PCDDs and PCDFs have been detected in fish, wildlife, and human adipose tissue, milk, and serum [5].

Each isomer has its own unique chemical and toxicological properties. The most toxic of the PCDD and PCDF isomers is 2,3,7,8-tetrachlorodibenzo-*p*-dioxin (2,3,7,8-TCDD), one of the 22 possible congeners of tetrachlorodibenzo-*p*-dioxin [10]. Toxicity equivalency factors (TEFs) have been developed by the EPA relating the toxicities of other PCDD and PCDF isomers to that of 2,3,7,8-TCDD [11]. The biochemical mechanisms leading to the toxic response resulting from exposure to PCDDs and PCDFs are not known in detail, but experimental data suggest that an important role in the development of systemic toxicity resulting from exposure to these chemicals is played by an intracellular protein, the Ah receptor. This receptor binds halogenated polycyclic aromatic molecules, including PCDDs and PCDFs. In several mouse strains, the expression of toxicity of 2,3,7,8-TCDD-related compounds, including cleft palate formation, liver damage, effects on body weight gain, thymic involution, and chloracnegenic response, has been correlated with their binding affinity for the Ah receptor, and with their ability to induce several enzyme systems [11].

Toxicity Equivalency Factors (TEF) for PCDD and PCDF Isomers [11]

Isomer	TEF
Total TetraCDD	1
2,3,7,8-TCDD	1
Other TCDDs	0.01
Total PentaCDDs	0.5
2,3,7,8-PentaCDDs	0.5
Other PentaCDDs	0.005
Total HexaCDDs	0.04
2,3,7,8-HexaCDDs	0.04
Other HexaCDDs	0.0004
Total HeptaCDDs	0.001
2,3,7,8-HeptaCDDs	0.001
Other HeptaCDDs	0.00001
Total TetraCDFs	0.1
2,3,7,8-TetraCDF	0.1
Other TetraCDFs	0.001
Total PentaCDFs	0.1
2,3,7,8-PentaCDFs	0.1
Other PentaCDFs	0.001
Total HexaCDFs	0.01
2,3,7,8-HexaCDFs	0.01
Other HexaCDFs	0.0001
Total HeptaCDFs	0.001
2,3,7,8-HeptaCDFs	0.001
Other HeptaCDFs	0.00001

In natural systems, PCDDs and PCDFs are typically associated with sediments, biota, and the organic carbon fraction of ambient waters [7]. Congener-specific analyses have shown that the 2,3,7,8-

substituted PCDDs and PCDFs were the major compounds present in most sample extracts [5]. Results from limited epidemiology studies are consistent with laboratory-derived threshold levels to 2,3,7,8-TCDD impairment of reproduction in avian wildlife. Population declines in herring gulls (*Larus argentatus*) on Lake Ontario during the early 1970s coincided with egg concentrations of 2,3,7,8-TCDD and related chemicals expected to cause reproductive failure based on laboratory experiments (2,3,7,8-TCDD concentrations in excess of 1,000 pg/g). Improvements in herring gull reproduction through the mid-1980s were correlated with declining 2,3,7,8-TCDD concentrations in eggs and lake sediments [7]. Based on limited information on isomer-specific analysis from animals at different trophic levels, it appears that at higher trophic levels, i.e., fish-eating birds and fish, there is a selection of the planar congeners with the 2,3,7,8-substituted positions [12].

PCDDs and PCDFs are accumulated by aquatic organisms through exposure routes that are determined by the habitat and physiology of each species. With log K_{ow}>5, exposure through ingestion of contaminated food becomes an important route for uptake in comparison to respiration of water [7]. The relative contributions of water, sediment, and food to uptake of 2,3,7,8-TCDD by lake trout in Lake Ontario were examined by exposing yearling lake trout to Lake Ontario smelt and sediment from Lake Ontario along with water at a 2,3,7,8-TCDD concentration simulated to be at equilibrium with the sediments. Food ingestion was found to contribute approximately 75 percent of total 2,3,7,8-TCDD [7]. There have been a number of bioconcentration studies of 2,3,7,8-TCDD using model ecosystem and single species exposure. Although there is variation in the actual BCF values, in general, the algae and plants have the lowest BCF values, on the order of a few thousand. A log BCF value of 4.38 has been reported for the snail *Physa* sp. Crustacea and insect larvae appear to have the next highest BCF values, followed by several species of fish, with the highest log BCF value of 4.79 [12].

Exposure of juvenile rainbow trout to 2,3,7,8-TCDD and -TCDF in water for 28 days resulted in adverse effects on survival, growth, and behavior at extremely low concentrations. A no-observed-effects concentration (NOEC) for 2,3,7,8-TCDD could not be determined because the exposure to the lowest dose of 0.038 ng/l resulted in significant mortality [13]. A number of biological effects have been reported in fish following exposure to 2,3,7,8-TCDD including enzyme induction, immunological effects, wasting syndrome, dermatological effects, hepatic effects, hematological effects, developmental effects, and cardiovascular effects [12].

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Plants									
Oedogonium cardiacum, Green algae			1.34 mg/kg (whole body)[4]	Growth, NOED				[35]	L; no effect on growth
Lemna minor, Duckweed			0.00614 mg/kg (whole body)[4]	Growth, NOED				[35]	L; no observed effect
Invertebrates									
Nereis virens, Sandworm	656±97 pg/g dw; (n = 6)		422±103 pg/g dw (whole body)				~0.5	[8,14]	L; 180-day exposure; sediment TOC was 57 mg/kg; ~ indicates approximate value, as numbers were estimated from bar graphs.
Physa sp., Snail			0.364 mg/kg (whole body)[4]	Mortality, NOED				[35]	L; no effect on survival

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Macoma nasuta, Clam	656±97 pg/g dw; (n = 6)		142 ± 20 pg/g dw				~0.9	[8,14]	L; 120-day exposure; sediment TOC was 57 mg/kg; ~ indicates approximate value, as numbers were estimated from bar graphs.
Daphnia magna, Cladaceran			2.08 mg/kg (whole body)[4]	Mortality, NOED				[35]	L; no effect on survival
Palaemonetes pugio, Grass shrimp	656±97 pg/g dw; (n = 6)		138 ± 20 pg/g dw				~0.7	[8,14]	L; 28-day exposure; sediment TOC was 57 mg/kg ~ indicates approximate value, as numbers were estimated from bar graphs.
Pacifastacus leniusculus, Crayfish			0.003 mg/kg (whole body)[4]	Mortality, ED25				[31]	L; 25% mortality after 40 days
			0.03 mg/kg (whole body)[4]	Mortality, ED50				[31]	L; lethargy, 50% to 66% increase in mortality

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.003 mg/kg (whole body)[4]	Behavior, LOED				[31]	L; lack of avoidance response
			0.003 mg/kg (whole body)[4]	Physiological, LOED				[31]	L; significant induction of cytochrome P450
			0.003 mg/kg (whole body)[4]	Physiological, LOED				[31]	L; significant induction of liver enzymes (cytochrome P450)
			0.1 mg/kg (whole body)[4]	Morphology, NOED				[31]	L; no significant pathology at highest dose
			0.0003 mg/kg (whole body)[4]	Mortality, NOED				[31]	L; no effect on mortality
			0.0003 mg/kg (whole body)[4]	Physiological, NOED				[31]	L; no significant induction of liver enzymes (cytochrome P450)
Callinectes sapidus, Blue crab	32.2 ppt[5] (TOC = 3.2%) 52.8 ppt[5] (TOC = 3.9%)		8.2 ppt[5] (hepatopancreas) (% lipid = 7.6)			-0.72	0.089	[15]	F; northeastern Florida; bleach-kraft paper mill receiving stream; BAF and BSAF calculated using mean of two sediment concentrations.

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Chironomus tentans, Midge			0.47 mg/kg (whole body)	Growth, NOED				[44]	L; concentrations are lipid
Fishes									
Oncorhynchus mykiss (Salmo gairdneri), Rainbow trout		water exposure 0.038 ng/L	1.0 µg/kg[5]	28-day LOEC (survival, growth)	4.41			[13]	L
		water exposure 0.382 ng/L	10.95 ng/g[5] (whole body)		4.46				L; 6-hour exposure period
Oncorhynchus mykiss, Rainbow trout			0.00388 mg/kg (extractable lipid)[4]	Growth, LOED				[32]	L; reduced growth, exposed fish weighed 50 g vs. 130 g for controls
			0.00371 mg/kg (liver)[4]	Growth, LOED				[32]	L; reduced growth, exposed fish weighed 50 g vs. 130 g for controls
			0.00026 mg/kg (muscle)[4]	Growth, LOED				[32]	L; reduced growth, exposed fish weighed 50 g vs. 130 g for controls

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.00065 mg/kg (whole body)[4]	Growth, LOED				[32]	L; reduced growth, exposed fish weighed 50 g vs. 130 g for controls
			0.00388 mg/kg (etractable lipid)[4]	Morphology, LOED				[32]	L; livers enlarged to nearly twice the size of control fish livers, fin rot
			0.00371 mg/kg (liver)[4]	Morphology, LOED				[32]	L; livers enlarged to nearly twice the size of control fish livers, fin rot
			0.00026 mg/kg (muscle)[4]	Morphology, LOED				[32]	L; livers enlarged to nearly twice the size of control fish livers, fin rot
			0.00065 mg/kg (whole body)[4]	Morphology, LOED				[32]	L; livers enlarged to nearly twice the size of control fish livers, fin rot
			0.00388 mg/kg (extractable lipid)[4]	Mortality, LOED				[32]	L; lethal to 7 of 90 fish over 139 days
			0.00371 mg/kg (liver)[4]	Mortality, LOED				[32]	L; lethal to 7 of 90 fish over 139 days
			0.00026 mg/kg (muscle)[4]	Mortality, LOED				[32]	L; lethal to 7 of 90 fish over 139 days

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.00065 mg/kg (whole body)[4]	Mortality, LOED				[32]	L; lethal to 7 of 90 fish over 139 days
Oncorhynchus mykiss, Rainbow trout			0.01 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80-day LD50 for mortality
			0.001 mg/kg (whole body)[4]	Growth, LOED				[36]	L; reduction in body weight
			0.025 mg/kg (whole body)[4]	Morphology, LOED				[36]	L; fin necrosis, hyperpigmentation
Oncorhynchus mykiss, Rainbow trout			0.000315 mg/kg (carcass)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000102 mg/kg (gastrointestinal tract)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000244 mg/kg (gill)[4]	Growth, NOED				[38]	L; no effect on growth
			0.00007 mg/kg (heart)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000092 mg/kg (kidney)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000072 mg/kg (liver)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000355 mg/kg (pyloric caeca)[4]	Growth, NOED				[38]	L; no effect on growth

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000029 mg/kg (skeletal muscle)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000201 mg/kg (skin)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000085 mg/kg (spleen)[4]	Growth, NOED				[38]	L; no effect on growth
			0.00327 mg/kg (visceral fat)[4]	Growth, NOED				[38]	L; no effect on growth
			0.00025 mg/kg (whole body)[4]	Growth, NOED				[38]	L; no effect on growth
			0.000315 mg/kg (carcass)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000102 mg/kg (gastrointestinal tract)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000244 mg/kg (gill)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.00007 mg/kg (heart)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000092 mg/kg (kidney)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000072 mg/kg (liver)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000355 mg/kg (pyloric caeca)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000029 mg/kg (skeletal muscle)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000201 mg/kg (skin)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000085 mg/kg (spleen)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.00327 mg/kg (visceral fat)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.00025 mg/kg (whole body)[4]	Morphology, NOED				[38]	L; no effect on fin necrosis or hemorrhage
			0.000315 mg/kg (carcass)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000102 mg/kg (gastrointestinal tract)[4]	Mortality, NOED				[38]	L; no effect on mortality

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000244 mg/kg (gill)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.00007 mg/kg (heart)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000092 mg/kg (kidney)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000072 mg/kg (liver)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000355 mg/kg (pyloric caeca)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000029 mg/kg (skeletal muscle)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000201 mg/kg (skin)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.000085 mg/kg (spleen)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.00327 mg/kg (visceral fat)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.00025 mg/kg (whole body)[4]	Mortality, NOED				[38]	L; no effect on mortality
			0.00452 mg/kg (whole body)[4]	Survival, ED50				[13]	L; exposure concentration is the mean of measured TCDD concentration

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus mykiss, Rainbow trout			0.0000047 mg/kg (liver)[4]	Biochemical, LOED				[40]	L; significant increase in liver ethoxyresorufin O-deethylase (EROD)
			0.000038 mg/kg (liver)[4]	Biochemical, LOED				[40]	L; significant increase in liver ethoxyresorufin O-deethylase (EROD)
			0.000016 mg/kg (liver)[4]	Biochemical, LOED				[40]	L; significant increase in liver ethoxyresorufin O-deethylase (EROD)
Oncorhynchus mykiss, Rainbow trout			0.000439 mg/kg (whole body)[4]	Mortality, ED50				[42]	L; mortality from fertilization to swim-up; exposure dose calculated from text; residue measured in egg at 5-days post exposure; dosed for 48 hours and endpoint measured after approximately 24 days

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000421 mg/kg (whole body)[4]	Mortality, ED50				[42]	L; mortality from fertilization to swim-up; liposome used to carry dose; 93% of dose retained in egg and assumed to be in swim-up fry, flow rate = 8-12
			0.000279 mg/kg (whole body)[4]	Mortality, LOED				[42]	L; significant increase in mortality from hatch to swim-up at lowest exposure concentration tested; exposure dose calculated from text; residue measured in egg at 5-days post exposure; dosed for 48 hours and endpoint measured after approximately 24 days

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000437 mg/kg (whole body)[4]	Mortality, LOED				[42]	L; significant increase in mortality from hatch to swim-up; liposome used to carry dose; 93% of dose retained in egg and assumed to be in swim-up fry, flow rate = 8-12
			0.000291 mg/kg (whole body)[4]	Mortality, NOED				[42]	L; no significant increase in mortality from hatch to swim-up; liposome used to carry dose; 93% of dose retained in egg and assumed to be in swim-up fry, flow rate = 8 to 12
Oncorhynchus mykiss, Rainbow trout			0.00017 mg/kg (whole body)[4]	Mortality, ED50				[43]	L; estimated LD50s for 6 strains of rainbow trout, orig_con_wet ranged from 170 to 488; used low value; exposure concentration = 170 to 488

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Salmo trutta, Brown trout			5.2 pg/g[5] (fillet)			4.25-4.45		[22]	F; locations throughout Maine; a range of mean BAFs is presented; the values are means for locations throughout Maine, and the range is for BAFs calculated using river concentrations from years prior to the sampling date to account for declines in paper mill discharges
Salvelinus fontinalis, Brook trout			0.0006 mg/kg (whole body)[4]	Physiological				[33]	L; induction of hepatic EROD

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Salvelinus fontinalis, Brook trout			0.0012 mg/kg (whole body)[4]	Growth, NOED				[41]	L; no significant growth effect at highest target body burden; TCDD-spiked diet to produce desired body burden; abstract with minimal information
			0.0012 mg/kg (whole body)[4]	Mortality, NOED				[41]	L; no significant mortality at highest target body burden; TCDD-spiked diet to produce desired body burden; abstract with minimal information
			0.0012 mg/kg (whole body)[4]	Reproduction, LOED				[41]	L; significant delay in spawning; TCDD-spiked diet to produce desired body burden; abstract with minimal information

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.0006 mg/kg (whole body)[4]	Reproduction, NOED				[41]	L; no delay in spawning; TCDD-spiked diet to produce desired body burden; abstract with minimal information
Salvelinus fontinalis, Brook trout			0.0002 mg/kg (whole body)[4]	Mortality, ED50				[43]	L; estimated LD50
Amia calva, Bowfin			11.2 ppt[5] (liver) (n = 1)			-0.59	0.180	[15]	F; northeastern Florida; bleached-kraft paper mill receiving stream; BAF and BSAF calculated using mean of two sediment concen-trations. BAF = (pg TCDD/g tissue) ÷ (pg TCDD / g sediment); BSAF = (pg TCDD/g lipid) ÷ (pg TCDD / g TOC).
			18.6 ppt[5] (liver) (n = 1)			-0.36	0.255		
			46.1 ppt[5] (ovary) (n=1)			0.03	0.281		

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oncorhynchus kisutch, Coho salmon			0.000478 mg/kg (whole body)[4]	Growth, LOED				[39]	L; reduced growth
			0.000478 mg/kg (whole body)[4]	Mortality, LOED				[39]	L; reduced survival
			0.00217 mg/kg (whole body)[4]	Growth, NA				[39]	L; reduced growth
			0.00217 mg/kg (whole body)[4]	Mortality, NA				[39]	L; reduced survival
			0.000125 mg/kg (whole body)[4]	Behavior, NOED				[39]	L; no effect on food consumption or feeding
			0.000125 mg/kg (whole body)[4]	Growth, NOED				[39]	L; no effect on growth
Carp, (scientific name unknown)		water exposure 62 pg/L	2.2 µg/kg[5]	Death (71 days)				[16]	L
Salvelinus namaycush, Lake trout, (early life stage)		water exposure 20 ng/L	0.055 µg/kg[5] (egg)	48-hour LOEC (mortality)				[21]	L

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
		water exposure 10 ng/L	0.034 µg/kg[5] (egg)	48-hour NOEC (mortality)				[21]	L
		water exposure 62 ng/L	0.226 µg/kg[5] (egg)	48-hour LOEC (hatchability)				[21]	L
Salvelinus namaycush, Lake trout			0.000065 mg/kg (whole body)[4]	Mortality, ED50				[15]	L; lethal to 50% of sac fry
			0.000055 mg/kg (whole body)[4]	Mortality, LOED				[15]	L; lowest statistically significant increase in mortality of sac fry
			0.000226 mg/kg (whole body)[4]	Reproduction, L				[15]	L; reduced hatchability of eggs
			0.000035 mg/kg (whole body)[4]	Mortality, NOED				[15]	L; no effect on mortality of sac fry
Salvelinus namaycush, Lake trout			0.000044 mg/kg (whole body)[4]	Mortality, ED50				[34]	L; LD50 for sac fry mortality

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Salvelinus namaycush, Lake trout			0.000065 mg/kg (whole body)[4]	Mortality, ED50				[42]	L; mortality from fertilization to swim-up; exposure dose calculated from text; residue measured in egg at 5-days post exposure; dosed for 48 hours and endpoint measured after approximately 24 days
			0.000055 mg/kg (whole body)[4]	Mortality, LOED				[42]	L; significant increase in mortality from hatch to swim-up; exposure dose calculated from text; residue measured in egg at 5-days post exposure; dosed for 48 hours and endpoint measured after approximately 24 days

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000058 mg/kg (whole body)[4]	Mortality, LOED				[42]	L; significant increase in mortality from hatch to swim-up; high control mortality; liposome used to carry dose; 93% of dose retained in egg and assumed to be in swim-up fry, flow rate = 8-12
			0.000034 mg/kg (whole body)[4]	Mortality, NOED				[42]	L; no significant increase in mortality from hatch to swim-up; exposure dose calculated from text; residue measured in egg at 5-days post exposure; dosed for 48 hours and endpoint measured after approximately 24 days

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000044 mg/kg (whole body)[4]	Mortality, NOED				[42]	L; no significant increase in mortality from hatch to swim-up; high control mortality; liposome used to carry dose; 93% of dose retained in egg and assumed to be in swim-up fry, flow rate = 8 to 12
Salvelinus namaycush, Lake trout			0.000065 mg/kg (whole body)[4]	Mortality, ED50				[43]	L; estimated LD50
Carassius auratus, Goldfish			0.58-0.63 ng/g[5] (whole body)		4.39			[18]	L; fish were exposed for 120 hr; exposure water contained fly ash extract; concentrations were measured in water, but data were not presented

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Cyprinus carpio, Carp	170 pg/g[5]		120 pg/g[5]				0.27	[9]	F; Petenwell Reservoir, central Wisconsin; BSAF based on 8% tissue lipid content and 3.1% sediment organic carbon
Cyprinus carpio, Carp			0.0022 mg/kg (whole body)[4]	Behavior, LOED				[15]	L; difficulty swimming
			0.0022 mg/kg (whole body) [4]	Cellular, LOED				[15]	L; edema, body wall ulcers
			0.0022 mg/kg (whole body)[4]	Morphology, LOED				[15]	L; fin erosion, hemorrhage, morphologically resembling Blue Sac Disease
Cyprinus carpio, Carp			0.003 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80-day LD50 for mortality
Cyprinus carpio, Carp			0.0022 mg/kg (whole body)[4]	Mortality, LOED				[15]	L; increased mortality

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Danio rerio, Zebrafish			2.16 ng/g (egg)	ED50 (pericardial edema)				[23]	L; newly fertilized eggs were exposed for 1 hr to water containing graded concentrations of TCDD
			2.43 ng/g (egg)	ED50 (yolk sac edema)					
			2.45 ng/g (egg)	LD50					
Bracydanio rerio, Zebrafish			8.3 µg/kg[5]	LOEC (reproduction)				[24]	L; food exposure
			8.3 µg/kg[5]	LOEC (oogenesis)				[24]	L; food exposure
Pimephales promelas, Fathead minnow			17-2,042 µg/kg[5]	LD100				[17]	L; food exposure

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Catostomus commerson, White sucker			9.6 pg/g[5] (whole body)			4.89-5.03		[22]	F; locations throughout Maine; a range of mean BAFs is presented; the values are means for locations throughout Maine, and the range is for BAFs calculated using river concentrations from years prior to the sampling date to account for declines in paper mill discharges

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ictalurus nebulosus, Brown bullhead catfish	32.2 -52.8 ppt[5] (TOC = 3.2-3.9%)		1.8 ppt[5] (liver) (% lipid = 3.5)			-1.40	0.043	[15]	F; northeastern Florida; bleached-kraft paper mill receiving stream; BAF and BSAF calculated using mean of two sediment concentrations. BAF = (pg TCDD/g tissue) ÷ (pg TCDD/ g sediment); BSAF = (pg TCDD/g lipid) ÷ (pg TCDD / g TOC).
			2.6 ppt[5] (liver) (% lipid = 2.9)			-1.22	0.074		
			2.8 ppt[5] (liver) (% lipid = 3.2)			-1.15	0.073		
Ictalurus melas, Black bullhead			0.005 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80 day LD50 for mortality
			0.025 mg/kg (whole body)[4]	Morphology, LOED				[36]	L; fin necrosis, hyperpigmentation

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ictalurus punctatus, Channel catfish			0.0044 mg/kg (whole body)[4]	Mortality, ED10				[45]	L; radiolabelled compounds in sediment, compound leached into water for exposure; all fish died between days 14 and 15; body residues from dead fish
Gambusia affinis, Mosquito fish			0.0072 mg/kg (whole body)[4]	Mortality, ED10				[45]	L; radiolabelled compounds in sediment, compound leached into water for exposure; all fish died between days 14 and 15; body residues from dead fish
Oryzias latipes, Japanese medaka		Water exposure 2.2 ng/L	0.24 µg/kg[5] (embryo)	Lesions in embryos				[19]	L

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Oryzias latipes, Japanese medaka (juveniles)		water exposure 101 ± 26 pg/L (n = 23)	2,408 ±241 pg/g	Obvious signs of TCDD toxicity such as generalized edema, fin erosion, and discoloration in many of the exposed fish	4.38 non-steady state 5.71 predicted steady state			[20]	L; 12-day exposure period; lipid content 7.5%
Oryzias latipes, Japanese medaka			0.24 mg/kg (whole body)[4]	Lesions, ED50				[19]	L; ten replicates per treatment
			0.3 mg/kg (whole body)[4]	Lesions, LOED				[19]	L; 50% of embryos with lesions but no statistical significance analyzed; ten replicates per treatment
			0.1 mg/kg (whole body)[4]	Lesions, NOED				[19]	L; no significant incidence of lesions at lowest doseage tested; 10 replicates per treatment, resd_conc_wet value > 0.1

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Morone americana, White perch			1.2 pg/g[5]			3.48-3.88		[22]	F; locations throughout Maine; a range of mean BAFs is presented; the values are means for locations throughout Maine, and the range is for BAFs calculated using river concentrations from years prior to the sampling date to account for declines in paper mill discharges
Lepomis macrochirus, Bluegill			0.016 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80-day LD50 for mortality
			0.005 mg/kg (whole body)[4]	Growth, LOED				[36]	L; reduction in body weight
			0.025 mg/kg (whole body)[4]	Morphology, LOED				[36]	L; fin necrosis, hyperpigmentation

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Microperus dolomieu, Smallmouth bass			3.4 pg/g[5] (fillet)			4.06-4.39		[22]	F; locations throughout Maine; a range of mean BAFs is presented; the values are means for locations throughout Maine, and the range is for BAFs calculated using river concentrations from years prior to the sampling date to account for declines in paper mill discharges

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Micropterus samoides, Largemouth bass	32.2 ppt[5] (TOC=3.2%)		1.8 ppt[5] (liver) (% lipid =3.9)			-1.40	0.038	[15]	F; northeastern Florida; bleached kraft paper mill receiving stream; BAF and BSAF calculated using mean of two sediment concentrations. BAF = (pg TCDD / g tissue) ÷ (pg TCDD/ g sediment); BSAF = (pg TCDD/g lipid) ÷ (pg TCDD/ g TOC).
	52.8 ppt[5] (TOC=3.9%)		2.9 ppt[5] (liver) (% lipid =2.4)			-1.15	0.100		
			8.8 ppt[5] (ovary) (% lipid =7.6)			-0.68	0.096		
Micropterus salmoides, Largemouth bass			0.011 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80-day LD50 For Mortality
			0.025 mg/kg (whole body)[4]	Morphology, LOED				[36]	L; Fin Necrosis, Hyperpigmentation
Perca flavescens, Yellow perch			0.003 mg/kg (whole body)[4]	Mortality, ED50				[36]	L; 80-day LD50 for mortality
			0.005 mg/kg (whole body)[4]	Growth, LOED				[36]	L; reduction in body weight

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.025 mg/kg (whole body)[4]	Morphology, LOED				[36]	L; fin necrosis, hyperpigmentation
			0.000129 mg/kg (carcass)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000148 mg/kg (gastrointestinal tract)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000155 mg/kg (gill)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000077 mg/kg (heart)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000119 mg/kg (kidney)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000466 mg/kg (liver)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000143 mg/kg (pyloric caeca)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000009 mg/kg (skeletal muscle)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000041 mg/kg (skin)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000166 mg/kg (spleen)[4]	Growth, NOED				[37]	L; no effect on growth
			0.00277 mg/kg (visceral fat)[4]	Growth, NOED				[37]	L; no effect on growth

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000143 mg/kg (whole body)[4]	Growth, NOED				[37]	L; no effect on growth
			0.000129 mg/kg (carcass)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000148 mg/kg (gastrointestinal tract)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000155 mg/kg (gill)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000077 mg/kg (heart)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000119 mg/kg (kidney)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000466 mg/kg (liver)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000143 mg/kg (pyloric caeca)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000009 mg/kg (skeletal muscle)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000041 mg/kg (skin)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000166 mg/kg (spleen)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.00277 mg/kg (visceral fat)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000143 mg/kg (whole body)[4]	Morphology, NOED				[37]	L; no effect on fin necrosis or hemorrhage
			0.000129 mg/kg (carcass)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000148 mg/kg (gastrointestinal tract)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000155 mg/kg (gill)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000077 mg/kg (heart)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000119 mg/kg (kidney)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000466 mg/kg (liver)[4]	Mortality, NOED				[37]	L; no effect on mortality

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.000143 mg/kg (pyoric ceca)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000009 mg/kg (skeletal muscle)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000041 mg/kg (skin)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000166 mg/kg (spleen)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.00277 mg/kg (visceral fat)[4]	Mortality, NOED				[37]	L; no effect on mortality
			0.000143 mg/kg (whole body)[4]	Mortality, NOED				[37]	L., no effect on mortality
Salmonids							0.059	[46]	F

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Aix sponsa, Wood duck			pg/g (eggs): Site 1 geometric mean: 36 (1.6 to 482) Site 2 geometric mean: 14 (0.8-74) Site 3 geometric mean: 4.2 (<1 to 19) Site 4 geometric mean: 0.01 (<1 to 0.5)	% eggs hatched: 47% (9.7 SE) 62% (10.1 SE) 79% (3.8 SE) 93% (3.4 SE)				[29]	F; central Arkansas; egg TEFs and hatching success and duckling production were negatively correlated; clutch size was similar among wetland Sites 1-3 which were 9, 17, and 58 km downstream from point source of contamination. respectively, and Site 4 which was 111 km away on a separate drainage; duckling abnor-malities were also noted
Aix sponsa, Wood duck									Threshold range of reduced productivity was > 20-50 ppt TEF.

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Falco peregrinus, Peregrine falcon			11 ng/g (eggs) (n= 6)	11.4% eggshell thinning				[26]	F; Kola Peninsula, Russia
Haliaeetus leucocephalus, Bald eagle chicks			Powell River site: 2,200 ng/kg lipid weight basis (yolk sac) Reference site: 300 ng/kg lipid weight basis (yolk sac)	A nearly 6-fold greater incidence of an hepatic cytochrome P4501A cross-reactive protein was induced in chicks from Powell River site as compared to the reference ($p < 0.05$). No significant concentration-related effects were found for morphological, physiological, or histological parameters.				[25]	F; southern coast of British Columbia; eggs were collected from nests and hatched in the lab; ~ indicates value was taken from a figure.

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Sterna forsteri, Forster's tern			Lake Poygan site: 8.0 pg/g; (egg) (n = 6) Green Bay site: 37.3 pg/g; (egg) (n = 6)	Birds from Green Bay had increased incubation period, reduced hatchability, lower body weight, increased liver to body weight ratio, and occurrence of edema when compared to birds from Lake Poygan. There was a significantly higher incidence of congenital abnormalities in dead embryos and chicks from Green Bay.				[27]	F; Green Bay, Lake Michigan, and Lake Poygan, Wisconsin

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Ardea herodias, Great blue heron chicks			Nicomekl site: 10±0.9 ng/kg; (egg) (n = 11)					[28]	L; eggs were collected from three British Columbia colonies with different levels of contamination and incubated in the laboratory
			Vancouver site: 135±49.6 ng/kg (egg) (n = 12)	Depression of growth compared to Nicomekl site. Presence of edema.					
			Crofton site: 2 11±33.7 ng/kg (egg) (n = 6)	Depression of growth compared to Nicomekl site. Presence of edema.					

Summary of Biological Effects Tissue Concentrations for 2,3,7,8-TCDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mustela vison, Mink	Diet: 2 pg/g[5]		21 pg/g[5] (liver)	LOAEL; reduced kit body weights followed by reduced survival		log BMF= 1.05		[30]	L; BMF = biomagnification factor = v_l/v_d, v_l = lipid-normalized concentration in tissue; v_d = lipid-normalized dietary concentration
	Diet: 3 pg/g[5]		34 pg/g[5] (liver)	Reduced kit body weights followed by reduced survival		log BMF = 1.06			
	Diet: 7 pg/g[5]		50 pg/g[5] (liver)	Significant decrease in number of live kits whelped per female		log BMF = 1.04			

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.
[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed and the reader is strongly urged to consult the publication to confirm the information presented here.
[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): **CASRN:** 72-54-8
1,1′-(2,2-DICHLOROETHYLIDENE)BIS(4-CHLOROBENZENE),
p,p′-DICHLORODIPHENYLDICHLOROETHANE
4,4′-DICHLORODIPHENYLDICHLOROETHANE

Chemical Characteristics

Solubility in Water: 0.16 mg/L at 24°C [1]

Half-Life: 2.0-15.6 years based on biodegradation of DDD in aerobic soils under field conditions [2]

Log K_{ow}: 6.10 [3]

Log K_{oc}: 6.0 L/kg organic carbon

Human Health

Oral RfD: Not available [4]

Confidence: —

Critical Effect: Lung tumors in male and female mice, liver tumors in male mice, thyroid tumors in male rats

Oral Slope Factor: 2.4×10^{-1} per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for DDD in wildlife were not calculated in the studies reviewed. However, based on the data presented in one study reviewed, log BCFs for birds from the lower Detroit River ranged from 4.97 to 5.22. Concentrations of DDD in birds were 3.5 to 6.1 times higher than those in sediment.

Food Chain Multipliers: Biomagnification factors of 3.2 and 85 were determined for DDT and DDE, respectively, from alewife to herring gulls in Lake Ontario [5]. A study of arctic marine food chains measured biomagnification factors for DDE that ranged from 17.6 to 62.2 for fish to seal, 0.3 to 0.7 for seal to bear, and 10.7 for fish to bear [6].

Aquatic Organisms

Partitioning Factors: Partitioning factors for DDD in aquatic organisms were not calculated in the studies reviewed. However, the data from one study reviewed showed BCFs of 17,600 for oligochaetes and 565,000 for carp. Ratios of DDD in tissue to sediment were 0.65 for oligochaetes and 21 for carp. BSAFs for clams ranged from 0.120 to 2.745 [22,25]. BSAFs for fish ranged from 0.079 to 2.379 [21,23,24,25].

Food Chain Multipliers: Food chain multipliers (FCMs) for trophic level 3 aquatic organisms were 18.5 (all benthic food web), 1.6 (all pelagic food web), and 11.3 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 37.4 (all benthic food web), 3.1 (all pelagic food web), and 17.8 (benthic and pelagic food web) [28].

Toxicity/Bioaccumulation Assessment Profile

DDT is very persistent in the environment due to its low vapor pressure, high fat solubility, and resistance to degradation and photooxidation. DDT is degraded to DDE under aerobic conditions and to DDD in anoxic systems [7]. These metabolites, DDD and DDE, are similar to DDT in both their stability and toxicity. Chronic effects of DDT and its metabolites on ecological receptors include changes in enzyme production, hormonal balance, and calcium metabolism, which may cause changes in behavior and reproduction. The high octanol-water partition coefficient of DDT indicates that it is easily accumulated in tissues of aquatic organisms. Laboratory studies have shown that these compounds are readily bioconcentrated in aquatic organisms, with reported log BCFs for DDT ranging from 3.08 to 7.65 and for DDE ranging from 4.80 to 5.26 [8].

Invertebrate species are generally more susceptible than fish species to effects associated with exposure to DDT in the water column [8]. In general, the low solubility of DDT and its metabolites in water suggests that water column exposures are likely to be lower than exposures from ingestion of food or sediment. Sediments contaminated with pesticides, including DDT, have been shown to affect benthic communities at low concentrations. Results of laboratory and field investigations suggest that chronic effects generally occur at total DDT concentrations in sediment exceeding 2 µg/kg [9]. Equilibrium partitioning methods predict that chronic effects occur at DDT concentrations in sediment of 0.6 to 1.7 µg/kg [10].

For fish, the primary route of uptake is via prey items, but both DDT and its metabolites can be accumulated through the skin or gills upon exposure to water. Short-term exposure to DDT concentrations of less than 1 µg/L have been reported to elicit toxic responses in both freshwater and marine fish [8]. DDT may also be transfered to embryos from contaminated adults. DDT concentrations of 1.1 to 2.4 mg/kg in fish embryos have been associated with fry mortality [11,12].

Eggshell thinning, embryo mortality, and decreased hatchling survival have been linked to chronic exposure to DDT and its metabolites in the diet of birds. Of the three compounds, evidence strongly indicates that DDE is responsible for most reproductive toxicity in avian species [13]. Measurements of residues in eggs of birds are a reliable indicator of adverse effects. There is a large amount of variability in sensitivity to DDT and its metabolites among bird species, with waterfowl and raptor species showing the greatest sensitivities. Studies have shown the brown pelican to be most susceptible to adverse effects, with eggshell thinning and depressed productivity occurring at 3.0 µg/g of DDE in the egg and total reproductive failure when residues exceed 3.7 µg/g [13].

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Tubifex sp., Oligochaetes	0.023 mg/kg n = 1	water = 0.85 ng/L n = 1	0.015 mg/kg n = 1					[14]	F; lower Detroit River
Macomona liliana, Mollusk	66.7 µg/kg OC		76.3 µg/kg lipid				1.144	[22]	F; %lipid = 2.95; %sed OC = 0.30
	1,096.0 µg/kg OC		765.2 µg/kg lipid				0.698	[22]	F; %lipid = 2.33; %sed OC = 0.73
	286.4 µg/kg OC		75.1 µg/kg lipid				0.262	[22]	F; %lipid = 2.57; %sed OC = 0.22
	20.0 µg/kg OC		54.9 µg/kg lipid				2.745	[22]	F; %lipid = 2.04; %sed OC = 0.25
	25.0 µg/kg OC		22.4 µg/kg lipid				0.894	[22]	F; %lipid = 3.13; %sed OC = 0.48
Austrovnus stutchburyi, Mollusk	66.7 µg/kg OC		42.4 µg/kg lipid				0.635	[22]	F; %lipid = 5.62; %sed OC = 0.30
	286.4 µg/kg OC		34.4 µg/kg lipid				0.120	[22]	F; %lipid = 4.85; %sed OC = 0.22
	20 µg/kg OC		27.7 µg/kg lipid				1.383	[22]	F; %lipid = 3.87; %sed OC = 0.25
	25 µg/kg OC		25.1 µg/kg lipid				1.002	[22]	F; %lipid = 4.27; %sed OC = 0.48

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Corbicula fluminea, Asian clam	58.8 µg/kg OC		82 µg/kg lipid				1.394	[25]	F; %lipid = 0.61; %sed OC = 1.19
	159.7 µg/kg OC		82 µg/kg lipid				0.513	[25]	F; %lipid = 0.61; %sed OC = 1.19
Fish									
Anguilla anguilla, Eel	126 µg/kg OC		10 µg/kg lipid				0.079	[26]	F; %lipid = 13; %sed OC = 32
Corogonus autumnalis, Omul (endemic whitefish)		particulate: 1.0 pg/L ± 1.0 n = 7 dissolved: 17 pg/L ±7.3 n = 7	0.0086-0.15 mg/kg lipid (whole body) n = 1						
Oncorhynchus, Salmo, Salvelinus sp., Salmonids	2,667 µg/kg OC		754.5 µg/kg lipid				0.283	[24]	F; %lipid = 11; %sed OC = 2.7
		0.000093 µg/L	83 µg/kg			5.93		[24]	F; %lipid = 11
Salvelinus fontinalis, Brook trout			4.79 mg/kg (whole body)[4]	Behavior, NOED				[18]	L; temperature selection after 24 h exposure to chemical

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Salvelinus namaycush, Lake trout			0.9 mg/kg (whole body)[4]	Mortality, LOED				[20]	L; survival of fry reduced
Leuciscus cephalus cabeda, Chub	478 µg/kg OC		378 µg/kg lipid				0.790	[21,27]	F; %lipid = 1.27; %sed OC = 2.76
Alburnus alburnus alborella, Bleak	478 µg/kg OC		769 µg/kg lipid				1.608	[21,27]	F; %lipid = 1.95; %sed OC = 2.76
Cyprinus carpio, Carp	0.023 mg/kg n = 1	water = 0.85 ng/L n = 1	0.48 ± 0.26 mg/kg n = 9					[14]	F; lower Detroit River; value is mean ± SD
Pimephales promelas, Fathead minnow			0.6 mg/kg (whole body)[4]	Reproduction, LOED				[17]	L; significantly different from control (p = 0.05)
Gambusia affinis, Mosquito fish			5.3 mg/kg (whole body)[4]	Mortality, NOED				[19]	L; no effect on survivorship after 3 days
Catastoma macrocheilus, Largescale sucker	530 µg/kg OC		1,261 µg/kg lipid				2.379	[23]	F; %lipid = 11.1; %sed OC = 1.0

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Cottus cognatus, Slimy sculpin	2667 µg/kg OC		587.5 µg/kg lipid				0.220	[24]	F; %lipid = 8; %sed OC = 2.7
		0.000093 µg/L	47 µg g/kg			5.70		[24]	F; %lipid = 8
Comephorus dybowskii, Pelagic sculpin		particulate: 1.0 pg/L ±1.0 n = 7 dissolved: 17 pg/L ±7.3 n = 7	0.12-0.16 mg/kg lipid (whole body) n = 1					[15]	F; Lake Baikal, Siberia
Wildlife									
Bucephala clangula, Goldeneye	0.023 mg/kg n = 1	water = 0.85 ng/L n = 1	0.080 ± 0.024 mg/kg n = 3					[14]	F; lower Detroit River; value is mean ± SD
Aythya affinis, Lesser scaup	0.023 mg/kg n = 1	water = 0.85 ng/L n = 1	0.093 ± 0.027 mg/kg n = 7					[14]	F; lower Detroit River; value is mean ± SD
Aythya marila, Greater scaup	0.023 mg/kg n = 1	water = 0.85 ng/L n = 1	0.14±0.045 mg/kg n = 3					[14]	F; lower Detroit River; value is mean ± SD

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDD

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Falco peregrinus, Peregrine falcon (eggs)			9 ng/g (eggs) n = 6	11.4% eggshell thinning				[16]	F; Kola Penninsula, Russia; n = number of clutches sampled
Phoca siberica, Baikal seal		particulate: 1.0 pg/L ± 1.0 n = 7 dissolved: 17 pg/L ± 7.3 n = 7	2.0-2.2 mg/kg[5] lipid (blubber) n = 1					[15]	F; Lake Baikal, Siberia

[1] Concentration units based on wet weight, unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): **CASRN:** 72-55-9
1,1′-(DICHLOROETHYLIDENE)BIS(4-CHLOROBENZENE),
p,p′-DICHLORODIPHENYLDICHLOROETHYLENE
4,4′-DICHLORODIPHENYLDICHLOROETHYLENE

Chemical Characteristics

Solubility in Water: 0.065 mg/L at 24°C [1]

Half-Life: 2.0 - 15.6 years based on biodegradation of DDD in aerobic soils under field conditions [2]

Log K_{ow}: 6.76 [3]

Log K_{oc}: 6.65 L/kg organic carbon

Human Health

Oral RfD: No data [4]

Confidence: —

Critical Effect: Liver tumors in mice and hamsters, thyroid tumors in female rats

Oral Slope Factor: 3.4×10^{-1} per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Based on the data presented in one study, log BCFs for birds collected from the lower Detroit River ranged from 5.92 to 6.36. Concentrations of DDE in birds were 40 to 108 times higher than in sediment. BSAFs were calculated for red-winged blackbird eggs and tree swallow eggs during a study in the Great Lakes area, with values ranging from 13 to 870 as reported in the attached summary table. BSAFs for tree swallow nestlings were 5 and 49.

Food Chain Multipliers: Biomagnification factors of 3.2 and 85 were determined for DDT and DDE, respectively, from alewife to herring gulls in Lake Ontario [5]. A study of arctic marine food chains measured biomagnification factors for DDE that ranged from 17.6 to 62.2 for fish to seal, 0.3 to 0.7 for seal to bear, and 10.7 for fish to bear [6].

Aquatic Organisms

Partitioning Factors: Partitioning factors for DDE in aquatic organisms were not calculated in the studies reviewed. However, the data showed ratios of DDT in tissue to sediment of 0.49 for oligochaetes and 32 for fish from the lower Detroit River. Ratios of DDT in lipid to sediment for three fish species from Rio de la Plata, Argentina ranged from 87 to 26,000. BSAFs for clams ranged from 1.2313 to

107.7 [15,41,36]. BSAFs for dover sole collected in southern California ranged from 1.7 to 3.4. BSAFs for other species ranged from 1.274 to 140.

Food Chain Multipliers: Food chain multipliers (FCMs) for trophic level 3 aquatic organisms were 23.7 (all benthic food web), 1.7 (all pelagic food web), and 14.4 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 57.5 (all benthic food web), 3.7 (all pelagic food web), and 26.7 (benthic and pelagic food web) [46].

Toxicity/Bioaccumulation Assessment Profile

DDT is very persistent in the environment due to its low vapor pressure, high fat solubility, and resistance to degradation and photooxidation. DDT is degraded to DDE under aerobic conditions and to DDD in anoxic systems [7]. These metabolites, DDD and DDE, are similar to DDT in both their stability and toxicity. Chronic effects of DDT and its metabolites on ecological receptors include changes in enzyme production, hormonal balance, and calcium metabolism, which may cause changes in behavior and reproduction. The high octanol-water partition coefficient of DDT indicates that it is easily accumulated in tissues of aquatic organisms. Laboratory studies have shown that these compounds are readily bioconcentrated in aquatic organisms, with reported log BCFs for DDT ranging from 3.08 to 6.65 and for DDE ranging from 4.80 to 5.26 [8].

Invertebrate species are generally more susceptible than fish species to effects associated with exposure to DDT in the water column [8]. In general, the low solubility of DDT and its metabolites in water suggests that water column exposures are likely to be lower than exposures from ingestion of food or sediment. Sediments contaminated with pesticides, including DDT, have been shown to impact benthic communities at low concentrations. Results of laboratory and field investigations suggest that chronic effects generally occur at total DDT concentrations in sediment exceeding 2 µg/kg [9]. Equilibrium partitioning methods predict that chronic effects occur at DDT concentrations in sediment of 0.6 to 1.7 µg/kg [10].

For fish, the primary route of uptake is via prey items, but both DDT and its metabolites can be accumulated through the skin or gills upon exposure to water. Short-term exposure to DDT concentrations of less than 1 µg/L have been reported to elicit toxic responses in both freshwater and marine fish [8]. DDT may also be transferred to embryos from contaminated adults. DDT concentrations of 1.1 to 2.4 mg/kg in fish embryos have been associated with fry mortality [11,12].

Eggshell thinning, embryo mortality, and decreased hatchling survival have been linked to chronic exposure to DDT and its metabolites in the diet of birds. Of the three compounds, evidence strongly indicates that DDE is responsible for most reproductive toxicity in avian species [13]. Measurements of residues in eggs of birds are a reliable indicator of adverse effects. There is a large amount of variability in sensitivity to DDT and its metabolites among bird species, with waterfowl and raptor species showing the greatest sensitivities. Studies have shown the brown pelican to be most susceptible to adverse effects, with eggshell thinning and depressed productivity occurring at 3.0 µg/g of DDE in the egg and total reproductive failure when residues exceed 3.7 µg/g [13].

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Invertebrates									
Tubifex sp., Oligochaetes	0.012 mg/kg (n = 1)	Surface water 0.57 ng/L (n = 1)	0.0059 mg/kg (n = 1)					[14]	F; lower Detroit River; value is mean ± SD
Viviparus conectus, Gastropod mollusk	294 µg/kg OC		368 µg/kg lipid				1.2517	[36]	F; %lipid = 7.06; %sed OC = 1.02
Unio elongatulus, Bivalve mollusk	294 µg/kg OC		362 µg/kg lipid				1.2313	[36]	F; %lipid = 10.49; %sed OC = 1.02
Mollusks (unspecified)	99.67 µg/kg OC		229 µg/kg lipid				2.298	[37]	F; %lipid = 1.1; %sed OC = 2.8
Macomona liliana, Mollusk	36.67 µg/kg OC		522.20 µg/kg lipid				14.241	[38]	F; %lipid = 2.95; %sed OC = 0.30
	35.62 µg/kg OC		573.39 µg/kg lipid				16.097	[38]	F; %lipid = 2.33; %sed OC = 0.73
	36.36 µg/kg OC		278.21 µg/kg lipid				7.652	[38]	F; %lipid = 2.57; %sed OC = 0.22
	20 µg/kg OC		328.92 µg/kg lipid				16.446	[38]	F; %lipid = 2.04; %sed OC = 0.25

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
	6.25 µg/kg OC		61.34 µg/kg lipid				9.814	[38]	F; %lipid = 3.13; %sed OC = 0.48
Austrovenus stutchburyi, Mollusk	36.67 µg/kg OC		141.64 µg/kg lipid				3.863	[38]	F; %lipid = 5.62; %sed OC = 0.30
	35.62 µg/kg OC		148.75 µg/kg lipid				4.176	[38]	F; %lipid = 5.21; %sed OC = 0.73
	36.36 µg/kg OC		57.94 µg/kg lipid				1.594	[38]	F; %lipid = 4.85; %sed OC = 0.22
	20 µg/kg OC		59.95 µg/kg lipid				2.998	[38]	F; %lipid = 3.87; %sed OC = 0.25
	6.25 µg/kg OC		10.54 µg/kg lipid				1.686	[38]	F; %lipid = 4.27; %sed OC = 0.48
Corbicula fluminea, Asian clam	13 µg/kg OC		1,400 µg/kg lipid				107.7	[15]	F; %lipid not reported; %sed OC = 2.3
Corbicula fluminea, Asian clam	(0-5 cm) 0.3 ng/g dw	Surface water 1.8 ng/L	1.4 µg/g lipid (whole tissue)					[15]	F; Rio de La Plata, Argentina; lipid content 2.4-3.8%
	0.6 ng/g dw		1.4 µg/g lipid (whole tissue)						
Corbicula fluminea, Asian clam	9,664 µg/kg OC		540,984 µg/kg lipid				55.979	[41]	F; %lipid = 0.61; %sed OC = 0.19
	168 µg/kg OC		4,098 µg/kg lipid				24.393	[41]	F; %lipid = 0.61; %sed OC = 0.19

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
	210 µg/kg OC		2,131 µg/kg lipid				10.148	[41]	F; %lipid = 0.61; %sed OC = 0.19
Astacidae, Crayfish	99.67 µg/kg OC		177 µg/kg lipid				1.776	[37]	F; %lipid = 1.3; %sed OC = 2.8
Chironomus riparius, Midge			1.6 mg/kg (whole body)[4]	Behavior, NOED				[31]	L; no effect on swimming behavior
			0.27 mg/kg (whole body)[4]	Behavior, NOED				[31]	L; no effect on swimming behavior
			0.1 mg/kg (whole body)[4]	Behavior, NOED				[31]	L; no effect on swimming behavior
Chironomus riparius, Midge			7.35 mg/kg (whole body)[4]	Development, LOED				[34]	L; development time from egg to 4th instar decreased from 22-25 days to 19-21 days
			3.75 mg/kg (whole body)[4]	Development, NOED				[34]	L; no effect on developmental period of larvae
Fishes									
Anguilla anguilla, Eel	5 µg/kg OC		156 µg/kg lipid				31.200	[43]	F; %lipid = 7; %sed OC = 7

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
	5 µg/kg OC		213 µg/kg lipid				42.600	[43]	F; %lipid = 7; %sed OC = 14
	32 µg/kg OC		2117 µg/kg lipid				66.156	[43]	F; %lipid = 6; %sed OC = 18
	76 µg/kg OC		849 µg/kg lipid				11.171	[43]	F; %lipid = 10; %sed OC = 12
	23 µg/kg OC		658 µg/kg lipid				28.609	[43]	F; %lipid = 10; %sed OC = 12
	72 µg/kg OC		2,176 µg/kg lipid				30.222	[43]	F; %lipid = 13; %sed OC = 32
Oncorhynchus mykiss, Rainbow trout			0.15 mg/kg (fat)[4]	Growth, ED40				[29]	L; 40% decrease in growth relative to control
			0.15 mg/kg (fat)[4]	Physiological, ED30				[29]	L; 30% decrease in hemoglobin content relative to control
			0.15 mg/kg (fat)[4]	Physiological, ED30				[29]	L; 30% increase in liver size relative to control
			0.08 mg/kg (fat)[4]	Physiological, ED35				[29]	L; 35% increase in kidney size relative to control

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Oncorhynchus, Salmo, *Salvelinus* spp., Salmonids	1,889 µg/kg OC		7,817 µg/kg lipid				4.139	[40]	F; %lipid = 11; %sed OC =2.7
		0.000076 µg/L	860 µg/kg			7.05		[40]	F; %lipid = 11
Oncorhynchus sp., Salmon	99.67 µg/kg OC		925 µg/kg lipid				9.281	[37]	F; %lipid = 13.1; %sed OC = 2.8
Prosopium williamsoni, Mountain whitefish	544.4 µg/kg OC		2,333 µg/kg lipid				4.285	[39]	F; %lipid = 12.0, %sed OC = 0.9
	3,500 µg/kg OC		4,460 µg/kg lipid (arithmetic mean of two samples)				1.274	[39]	F; %lipid = 12.25 %sed OC = 0.3
Coregonus autumnalis, Omul (endemic whitefish)		particulate: <14 pg/L n = 7 dissolved: 17±7.1 pg/L n = 7	0.31-0.50 mg/kg lipid n = 2						

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Salvelinus fontinalis, Brook trout			44.9 mg/kg (whole body)[4]	Behavior, LOED				[30]	L; temperature selection after 24 h exposure to chemical
Salvelinus namaycush, Lake trout			1.09 mg/kg (whole body)[4]	Mortality, LOED				[33]	L; survival of fry reduced
Alburnus alburnus alborella, Bleak fish	294 µg/kg OC		1,092 µg/kg lipid				3.7143	[36]	F; %lipid = 21.43; %sed OC = 1.02
Alburnus alburnus alborella, Bleak fish	358 µg/kg OC		2,113 µg/kg lipid				5.9022	[35, 45]	F; %lipid = 1.95; %sed OC = 2.76
Chondrostoma soetta	294 µg/kg OC		1,179 µg/kg lipid				4.0102	[36]	F; %lipid = 9.75; %sed OC = 1.02
Cyprinus carpio, Common carp	99.67 µg/kg OC		4,209 µg/kg lipid				42.229	[37]	F, %lipid = 13.9; %sed OC = 2.8
Cyprinus carpio, Common carp	174 µg/kg OC		1,905 µg/kg lipid				10.948	[42]	F, %lipid = 8.4; %sed OC = 2.13

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Cyprinus carpio, Carp	0.012 mg/kg (n = 1)	Surface water 0.57 ng/L (n = 1)	0.38 ± 0.15 mg/kg (n = 9)					[14]	F; lower Detroit River; value is mean ± SD
Scardinius erythrophalmus, Rudd	294 µg/kg OC		1,473 µg/kg lipid				6.546	[36]	F; %lipid = 11.66; %sed OC = 1.02
Leuciscus cephalus, Chub	294 µg/kg OC		1,473 µg/kg lipid				5.0102	[36]	F; %lipid = 9.98; %sed OC = 1.02
Leuciscus cephalus cabeda, Chub	358 µg/kg OC		1,953 µg/kg lipid				5.4553	[35, 45]	F; %lipid = 1.27; %sed OC = 2.76
Rutilus pigus	294 µg/kg OC		728 µg/kg lipid				2.4762	[36]	F; %lipid = 12.63; %sed OC = 1.02
Rutilus rubilio	294 µg/kg OC		1,167 µg/kg lipid				3.9694	[36]	F; %lipid = 11.05; %sed OC = 1.02
Catostomus commersoni, White sucker	208 µg/kg OC		1,519 µg/kg lipid				7.303	[42]	F; %lipid = 7.9; %sed OC = 1.44

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
mixed *Catastoma* sp., Suckers	3,500 µg/kg OC		3,253 µg/kg lipid (arithmetic mean of two samples)				0.929	[39]	F; %lipid = 9.2; %sed OC = 0.3
Catastoma macrocheilus, Largescale sucker	3,010 µg/kg OC		7,477 µg/kg lipid				2.484	[39]	F; %lipid = 11.1; %sed OC = 1.0
Barbus barbus, Barbel	294 µg/kg OC		1,333 µg/kg lipid				4.5340	[36]	F; %lipid = 16.43; %sed OC = 1.02
Siluris glanis, Wels fish, juveniles	294 µg/kg OC		731 µg/kg lipid				2.4864	[36]	F; %lipid = 3.83; %sed OC = 1.02
Siluris glanis, Wels fish, adults	294 µg/kg OC		1,613 µg/kg lipid				5.4864	[36]	F; %lipid = 5.38; %sed OC = 1.02
Pimelodus albicans, Mandi	0.2 ng/g dw		0.6 µg/g lipid (n = 2) (muscle)					[15]	F; Rio de La Plata, Argentina; lipid content 4%
Pimelodus albicans, Mandi	20 µg/kg OC		600 µg/kg lipid				30.0	[15]	F; %lipid not reported; %sed OC = 1.0
Gambusia affinis, Mosquito fish			29.2 mg/kg (whole body)[4]	Mortality, NOED				[32]	L; no effect on survivorship after 3 days

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Ambloplites rupestris, Rock bass	99.67 µg/kg OC		365 µg/kg lipid				3.662	[37]	F; %lipid = 0.7; %sed OC = 2.8
Sunfish (unspecified)	99.67 µg/kg OC		254 µg/kg lipid				2.548	[37]	F; %lipid = 3.7; %sed OC = 2.8
Roccus chrysops, White bass	99.67 µg/kg OC		1,586 µg/kg lipid				15.913	[37]	F; %lipid = 1.8; %sed OC = 2.8
Micropterus salmoides, Smallmouth bass	99.67 µg/kg OC		1,352 µg/kg lipid				13.565	[37]	F; %lipid = 0.6; %sed OC = 2.8
Dorosoma cepedianum, Gizzard shad	99.67 µg/kg OC		382 µg/kg lipid				3.833	[37]	F; %lipid = 6.8; %sed OC = 2.8
Perca fluviatilis, Perch	294 µg/kg OC		3,390 µg/kg lipid				11.5306	[36]	F; %lipid = 5.84; %sed OC = 1.02
Stizostedion vitreum, Walleye	99.67 µg/kg OC		2,593 µg/kg lipid				26.016	[37]	F; %lipid = 1.2; %sed OC = 2.8

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Microstomus pacificus, Dover sole	27 µg/g dw (n = 5)		16.0 µg/g (n = 5) (muscle)			log MBAF -0.26	1.7	[16]	F; Southern California Bight; modified bioaccumulation factor (MBAF) = C_{org} ww/ C_{sed} dw; water content of tissue was not measured
			210 µg/g (n = 3) (liver)			0.79	2.0		
	0.09 µg/g dw (n = 10)		0.24 µg/g (n = 10) (muscle)			log MBAF 0.43	1.8		
			0.80 µg/g (n = 6) (liver)			1.79	3.4		
Oligosarcus jenynsi, Common name not available	5.7 ng/g dw		0.5 µg/g lipid (n = 7) (muscle)					[15]	F; Rio de La Plata, Argentina; lipid content 0.32%
Prochilodus platensis, Curimata	20 µg/kg OC		2,800 µg/kg lipid				140	[15]	F, %lipid not reported; %sed OC = 1.0
Prochilodus platensis, Curimata	0.2 ng/g dw		Three composite samples: 1.2 (n = 4), 5.2 (n = 4) and 2 (n = 5) µg/g lipid (muscle)					[15]	F; Rio de La Plata, Argentina; lipid content 1-12.7%

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Gar pike (unspecified)	99.67 µg/kg OC		11,986 µg/kg lipid				120.257	[37]	F; %lipid = 0.8; %sed OC = 2.8
Comephorus bybowskii, Pelagic sculpin,		particulate: <14 pg/L n = 7 dissolved: 17 pg/L ± 7.1 n = 7	0.74-0.76 mg/kg lipid n = 1					[17]	F; Lake Baikal, Siberia
Cottus cognatus, Slimy sculpin	1,889 µg/kg OC		2,375 µg/kg lipid				1.257	[40]	F; %lipid = 8; %sed OC = 2.7
		0.000076 µg/L	190 µg/kg			6.40		[40]	F; %lipid =8; %sed OC = 2.7
Wildlife									
Bucephala clangula, Goldeneye	0.012 mg/kg (n = 1) seston = 0.10 mg/kg	Surface water 0.57 ng/L (n = 1)	0.48 ± 0.18 mg/kg (whole body) (n = 3)					[14]	F; lower Detroit River; value is mean ± SD

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Aythya affinis, Lesser scaup	0.012 mg/kg (n = 1)	Surface water 0.57 ng/L (n = 1)	0.80 ± 0.33 mg/kg (whole body) (n = 7)					[14]	F; lower Detroit River; value is mean ± SD
Aythya marila, Greater scaup	0.012 mg/kg (n = 1)	Surface water 0.57 ng/L (n = 1)	1.3 ± 0.25 mg/kg (whole body) (n = 3)					[14]	F; lower Detroit River; value is mean ± SD
Falco peregrinus, Peregrine falcon			µg/g (egg): ≤15 15-30 >30	Young produced per active nest: 1.8 2.0 1.0				[26]	F; Alaska; young produced not adjusted for sample egg collected

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Aquila chrysaetos, Golden eagle			µg/g (egg): 0.1 0.1 0.2 0.3 0.3	Mean % eggshell thinning = 7% 1% 3% 4% 5%				[24]	F; Great Britain; percentage of thinning based on thickness index [24]
Haliaeetus leucocephalus, Bald eagle			10 µg/g (egg)	Mean percent eggshell thinning= 10%				[22]	F; Oregon and Washington
			µg/g (egg): <2.2 2.2-3.5 3.6-6.2 6.3-11.9 ≥12	Young produced per active nest: 1.0 1.0 0.5 0.3 0.2				[23]	F
Ardea herodias, Great blue heron			4 µg/g (egg) 5 µg/g (egg)	Mean percent eggshell thinning = 10% 13%				[18]	F; Washington

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Plegadis chihi, White-faced ibis				Mean percent eggshell thinning=				[20]	F; Nevada
			2 µg/g (egg)	12%					
			1 µg/g (egg)	8%					
				Young produced per active nest:				[21]	F; Nevada; young produced not adjusted for sample egg collected
			µg/g (egg):						
			≤1	1.8					
			1-4	1.8					
			4-8	1.3					
			8-16	0.8					
			>16	0.6					
Egretta thula, Snowy egret				Mean percent eggshell thinning=				[20]	F; Nevada; young produced not adjusted for sample egg collected
			1 µg/g (egg)	3%					
			2 µg/g (egg)	12%					
				Young produced per active nest:					
			µg/g (egg):						
			≤1	2.2					
			1-5	2.4					
			5-10	1.0					
			10-20	1.0					

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Sula bassanus, Northern gannet			µg/g (egg) 19	Mean % eggshell thinning = 17%				[19]	F; Quebec
Larus californicus, California gull			430 mg/kg (brain)[4]	Mortality, not available (NA)				[28]	L
			175 mg/kg (breast)[4]	Mortality, NA				[28]	L
			3,100 mg/kg (liver)[4]	Mortality, NA				[28]	L
			220 mg/kg (brain)[4]	NA, NA				[28]	L
			490 mg/kg (breast)[4]	NA, NA				[28]	L
			800 mg/kg (liver)[4]	NA				[28]	L
			750 mg/kg (liver)[4]	NA				[28]	L
Pelecanus occidentalis, Brown pelican			4.4 mg/kg (brain)[4]	Mortality, NA				[28]	L
			59.5 mg/kg (breast)[4]	Mortality, NA				[28]	L
			7.15 mg/kg (liver)[4]	Mortality, NA				[28]	L

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Agelaius phoeniceus, Red-winged blackbird (eggs)	40.5 ng/g TOC = 2.5%		3,088.1 ng/g				41.4	[25]	F; Great Lakes/St. Lawrence River basin; 12 wetlands sites; sediment concentration reported as wet weight concentration which may be a typographical error
	7.9 ng/g TOC = 21.0%		777.7 ng/g				372.7		
	373.1 ng/g TOC = 7.5%		648.7 ng/g				12.9		
	1,160.7 ng/g TOC = 12%		1,299.6 ng/g				13.2		
	10.4 ng/g TOC-18.5%		305.7 ng/g				113.3		
	65.4 ng/g TOC = 11.5%		826.2 ng/g				30.3		
	1.6 ng/g TOC = 10.5%		416.1 ng/g				582.4		
	0.8 ng/g TOC = 13.8%		145.1 ng/g				522		
	1.3 ng/g TOC = 11.1%		183.5 ng/g				326.4		
	3.0 ng/g TOC = 23.9%		117.6 ng/g				203.7		

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	**Sediment**	**Water**	**Tissue (Sample Type)**	**Effects**	**Log BCF**	**Log BAF**	**BSAF**	**Reference**	**Comments[3]**
Tachycineta bicolor, Tree swallow Nestlings			(whole body minus feet, beak, wings, and feathers)					[25]	F; Great Lakes/St. Lawrence River basin; 12 wetlands sites; sediment concentration reported as wet weight
	65.4 ng/g TOC = 11.5%		288.2 ng/g				548.9		
	0.8 ng/g TOC = 13.8%		22.4 ng/g						concentration which may be a typographical error
Eggs	65.4 ng/g TOC = 11.5%		794.7 ng/g				16.2		
	0.8 ng/g TOC = 13.8%		458.2 ng/g				868.6		
			3.5 µg/g (egg) (n = 6)	11.4% eggshell thinning				[27]	F; Kola Penninsula, Russia; n = number of clutches sampled

Summary of Biological Effects Tissue Concentrations for *p,p′*-DDE

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Phoca siberica, Baikal seal		particulate: <14 pg/L n = 7 dissolved: 17 pg/L ± 7.1 n = 7	43-44 mg/kg lipid n = 1					[17]	F; Lake Baikal, Siberia

[1] Concentration units based on wet weight unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from The Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): **CASRN:** 50-29-3
1,1′-(2,2,2-TRICHLOROETHYLIDENE)BIS(4-CHLOROBENZENE),
p,p′-DICHLORODIPHENYLTRICHLOROETHANE,
4,4′-DICHLORODIPHENYLTRICHLOROETHANE

Chemical Characteristics

Solubility in Water: 0.0031 - 0.0034 mg/L at 25°C [1]

Half-Life: 2.0 - 15.6 years based on biodegradation of DDD in aerobic soils under field conditions [2]

Log K_{ow}: 6.83 [3]

Log K_{oc}: 6.71 L/kg organic carbon

Human Health

Oral RfD: 5×10^{-4} mg/kg/day [4]

Confidence: Medium, uncertainty factor = 100

Critical Effect: Liver lesions in rats, liver tumors in mice and rats

Oral Slope Factor: 3.4×10^{-1} per (mg/kg)/day [4]

Carcinogenic Classification: B2 [4]

Wildlife

Partitioning Factors: Partitioning factors for DDT in wildlife were not calculated in the studies reviewed. However, based on the data in one study, log BCFs for birds from the lower Detroit River ranged from 4.81 to 5.01. Concentrations of DDT in birds were 2.1 to 3.3 times higher than in sediment.

Food Chain Multipliers: Biomagnification factors of 3.2 and 85 were determined for DDT and DDE, respectively, from alewife to herring gulls in Lake Ontario [5]. A study of arctic marine food chains measured biomagnification factors for DDE that ranged from 17.6 to 62.2 for fish to seal, 0.3 to 0.7 for seal to bear, and 10.7 for fish to bear [6].

Aquatic Organisms

Partitioning Factors: Based on the results from one study reviewed, the log BCF for carp collected from the lower Detroit River was 4.77. Ratios of DDT in lipids to sediment were 450 in clams and 1,250 to 11,000 in fish from the Rio de la Plata, Argentina. BSAFs for clams ranged from 0.060 to 302.326 [14,33,36]. BSAFs for fish ranged from 0.120 to 88.07.

Food Chain Multipliers: Food chain multipliers (FCMs) for trophic level 3 aquatic organisms were 22.5 (all benthic food web), 1.7 (all pelagic food web), and 13.7 (benthic and pelagic food web). FCMs for trophic level 4 aquatic organisms were 52.5 (all benthic food web), 3.6 (all pelagic food web), and 24.6 (benthic and pelagic food web) [39].

Toxicity/Bioaccumulation Assessment Profile

DDT is very persistent in the environment due to its low vapor pressure, high fat solubility, and resistance to degradation and photooxidation. DDT is degraded to DDE under aerobic conditions and to DDD in anoxic systems [7]. These metabolites, DDD and DDE, are similar to DDT in both their stability and toxicity. Chronic effects of DDT and its metabolites on ecological receptors include changes in enzyme production, hormonal balance, and calcium metabolism, which may cause changes in behavior and reproduction. The high octanol-water partition coefficient of DDT indicates that it is easily accumulated in tissues of aquatic organisms. Laboratory studies have shown that these compounds are readily bioconcentrated in aquatic organisms, with reported log BCFs for DDT ranging from 3.08 to 6.65 and for DDE ranging from 4.80to 5.26 [8].

Invertebrate species are generally more susceptible than fish species to effects associated with exposure to DDT in the water column [8]. In general, the low solubility of DDT and its metabolites in water suggests that water column exposures are likely to be lower than exposures from ingestion of food or sediment. Sediments contaminated with pesticides, including DDT, have been shown to affect benthic communities at low concentrations. Results of laboratory and field investigations suggest that chronic effects generally occur at total DDT concentrations in sediment exceeding 2 µg/kg [9]. Equilibrium partitioning methods predict that chronic effects occur at DDT concentrations in sediment of 0.6 to 1.7 µg/kg [10].

For fish, the primary route of uptake is via prey items, but both DDT and its metabolites can be accumulated through the skin or gills upon exposure to water. Short-term exposure to DDT concentrations of less than 1 µg/L have been reported to elicit toxic responses in both freshwater and marine fish [8]. DDT may also be transfered to embryos from contaminated adults. DDT concentrations of 1.1 to 2.4 mg/kg in fish embryos have been associated with fry mortality [11,12].

Eggshell thinning, embryo mortality, and decreased hatchling survival have been linked to chronic exposure to DDT and its metabolites in the diet of birds. Of the three compounds, evidence strongly indicates that DDE is responsible for most reproductive toxicity in avian species [13]. Measurements of residues in eggs of birds are a reliable indicator of adverse effects. There is a large amount of variability in sensitivity to DDT and its metabolites among bird species, with waterfowl and raptor species showing the greatest sensitivities. Studies have shown the brown pelican to be most susceptible to adverse effects, with eggshell thinning and depressed productivity occurring at 3.0 µg/g of DDE in the egg and total reproductive failure when residues exceed 3.7 µg/g [13].

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Macomona liliana, Mollusk	63.33 µg/kg OC		13.22 µg/kg lipid				0.209	[33]	F; %lipid = 2.95; %sed OC = 0.30
	76.71 µg/kg OC		33.91 µg/kg lipid				0.442	[33]	F; %lipid = 2.33; %sed OC = 0.73
	127.27 µg/kg OC		24.12 µg/kg lipid				0.190	[33]	F; %lipid = 2.57; %sed OC = 0.22
	20.83 µg/kg OC		7.35 µg/kg lipid				0.353	[33]	F; %lipid = 3.13; %sed OC = 0.48
Austrovenus stutchburyi, Mollusk	63.33 µg/kg OC		8.01 µg/kg lipid				0.126	[33]	F; %lipid = 5.62; %sed OC = 0.30
	76.71 µg/kg OC		7.29 µg/kg lipid				0.095	[33]	F; %lipid = 5.21; %sed OC = 0.73
	127.71 µg/kg OC		7.63 µg/kg lipid				0.060	[33]	F; %lipid = 4.85; %sed OC = 0.22
Corbicula fluminea, Asian clam	4.3 µg/kg OC		1,300 µg/kg lipid				302.326	[14]	F; %lipid = not reported; %sed OC = 2.3
Corbicula fluminea, Asian clam	3277 µg/kg OC		108,197 µg/kg lipid				33.017	[36]	F; %lipid = 0.61; %sed OC = 1.19

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
	67 µg/kg OC		508 µg/kg lipid				7.563	[36]	F; %lipid = 0.61; %sed OC = 1.19
	92 µg/kg OC		164 µg/kg lipid				1.774	[36]	F; %lipid = 0.61; %sed OC = 1.19
Corbicula fluminea, Asian clam	(0-5 cm) 2.9 ng/g dw		1.3 µg/g lipid (whole tissue)					[14]	F; Rio de La Plata, Argentina; lipid content 2.4-3.8%
Mercenaria mercenaria, Quahog clam			0.126 mg/kg (whole body)[4]	Behavior, NOED				[29]	L; No effect on feeding activity
Mya arenaria, Soft shell clam				NOED				[29]	L; no effect on feeding activity
Daphnia magna, Cladoceran			1.83 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship in 3 days
Diporeia spp., Amphipod			19.7 mg/kg (whole body)[4]	Mortality, NOED				[22]	L; no increase in mortality in 96 hours

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Gammarus fasciatus, Amphipod			0.336 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship in 3 days
Palaemonetes kadiakensis, Grass shrimp			0.1 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship in 3 days
Orconectes nais, Crayfish			0.0466 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship in 3 days
Ephemera danica, Mayfly			6 mg/kg (whole body)[4]	Growth, NOED				[20]	L
			6 mg/kg (whole body)[4]	Mortality, NOED					L
Hexagenia bilineata, Mayfly			0.336 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship after 3 days
Siphlonurus sp., Mayfly			0.216 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship after 3 days

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Libellula sp., Dragonfly			0.0144 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship after 2 days
Ischnura verticalis, Damselfly			0.075 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship after 2 days
Chironomus sp., Midge			0.44 mg/kg (whole body)[4]	Mortality, NOED				[23]	L; no effect on survivorship in 3 days
Chironomus riparius, Midge			0.83 mg/kg (whole body)[4]	Behavior, LOED				[24]	L; reduced swimming ability
			0.18 mg/kg (whole body)[4]	Behavior, NOED				[24]	L; no effect on swimming behavior
			0.08 mg/kg (whole body)[4]	Behavior, NOED				[24]	L; no effect on swimming behavior
Fishes									
Squalus acanthias, Spiny dogfish			0.1 mg/kg (whole body)[4]	Mortality, NOED				[32]	L; no effect on mortality in 24 hours

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Anguilla anguilla, Eel	23 µg/kg OC		158 µg/kg lipid				6.87	[37]	F; %lipid = 7; %sed OC = 7
	8 µg/kg OC		135 µg/kg lipid				16.88	[37]	F; %lipid = 7; %sed OC = 14
	14 µg/kg OC		1233 µg/kg lipid				88.07	[37]	F; %lipid = 6; %sed OC = 18
	25 µg/kg OC		221 µg/kg lipid				8.84	[37]	F; %lipid = 10; %sed OC = 12
	34 µg/kg OC		287 µg/kg lipid				8.44	[37]	F; %lipid = 10; %sed OC = 12
	144 µg/kg OC		1064 µg/kg lipid				7.39	[37]	F; %lipid = 13; %sed OC = 32
Oncorhynchus, Salmo, Salvelinus sp., Salmonids	667 µg/kg OC		727 µg/kg lipid				1.091	[35]	F; %lipid = 11; %sed OC = 2.7
		0.000019 µg/L	80 µg/kg lipid			6.62		[35]	F; %lipid = 11
Salmonids							1.67	[38]	F
Oncorhynchus kisutch, Coho salmon			95 mg/kg (whole body)[4]	Mortality, ED50				[27]	L; 50% mortality in 31 days

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Prosopium williamsoni, Mountain whitefish	244 µg/kg OC		417 µg/kg lipid				1.706	[34]	F; %lipid = 12.0; %sed OC = 0.9
	6,433 µg/kg OC		772 µg/kg lipid				0.120	[34]	F; %lipid = 12.25; %sed OC = 0.30
Corogonus autumnalis, Omul (endemic whitefish)		particulate: 5.1pg/L ± 2.3 n = 7 dissolved: 50 pg/L ± 23 n = 7	0.16-0.27 mg/kg[5] lipid (whole body) n = 2					[16]	F; Lake Baikal, Siberia
Salmo salar, Atlantic salmon			3 mg/kg (whole body)[4]	Morphology, NOED				[26]	L; no effect on metabolic rate or growth, resd_conc_wet value range 3.0-5.0
Salvelinus namaycush, Lake trout			3.9 mg/kg (whole body)[4]	Behavior, LOED				[21]	L; temperature selection after 24-hour exposure to chemical

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			27.8 mg/kg (whole body)[4]	Behavior, LOED				[21]	L; temperature selection after 24-hour exposure to chemical
Salvelinus namaycush, Lake trout			3.66 mg/kg (whole body)[4]	Mortality, LOED				[28]	L; survival of fry reduced
			2 mg/kg (whole body)[4]	Mortality, LOED				[28]	L; survival of fry reduced
Carassius auratus, Goldfish			5.1 mg/kg (whole body)[4]	Behavior, LOED				[31]	L; behavioral changes, loss of equilibrium, convulsions
Pimephales promelas, Fathead minnow			3.8 mg/kg (whole body)[4]	Reproduction, LOED				[19]	L; significantly different from control (p = 0.05)
			24 mg/kg (whole body)[4]	Reproduction, LOED				[19]	L; significantly different from control (p = 0.05)
Cyprinus carpio, Carp	0.012 mg/kg (n = 1)	Surface water 0.39 ng/L (n = 1)	0.023 ± 0.012 mg/kg (n = 9)					[15]	F; lower Detroit River; value is mean ± SD

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Mixed *Catastoma* sp., Suckers	6433 µg/kg OC		869 µg/kg lipid				0.135	[34]	F; %lipid = 9.2; %sed OC = 0.30
Catastoma macrocheilus, Largescale sucker	340 µg/kg OC		811 µg/kg lipid				2.385	[34]	F; %lipid = 11.1; %sed OC = 1.0
Pimelodus albicans, (Marine catfish)	0.4 ng/g dw		0.5 µg/g lipid (n = 7) (muscle)					[14]	F; Rio de La Plata, Argentina; lipid content 4%
Pimelodus albicans, Mandi	40.0 µg/kg OC		500 µg/kg lipid					[14]	F; %lipid = not reported; %sed OC = 1.0
Gambusia affinis, Mosquito fish			18.6 mg/kg (whole body)[4]	Mortality, NOED				[25]	L; no effect on survivorship after 3 days
Leuciscus idus, Golden ide			95 mg/kg (whole body)[4]	Mortality, NOED				[30]	L; no effect on survivorship in 3 days

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Lepomis macrochirus, Bluegill			4.2 mg/kg (whole body)[4]	Behavior, LOED				[31]	L; behavioral changes, loss of equilibrium, convulsions
Comephorus dybowskii, Pelagic sculpin		particulate: 5.1pg/L ± 2.3 n = 7 dissolved: 50 pg/L ± 23 n = 7	0.52-0.64 mg/kg lipid (whole body) n = 1					[16]	F; Lake Baikal, Siberia
Cottus cognatus, Slimy sculpin	667 µg/kg OC		362 µg/kg lipid				0.544	[35]	F; %lipid = 8; %sed OC = 2.7
		0.000019 µg/L	29 µg/kg lipid			6.18		[35]	F; %lipid = 8
Prochilodus platensis, common name not available	0.4 ng/g dw		Three composite samples (µg/g lipid): 2.4 (n = 4) (muscle) 9.3 (n = 4) (muscle) 4.3 (n = 5) (muscle)					[14]	F; Rio de La Plata, Argentina; lipid content 1-12.7%
Prochilodus platensis, Curimata	40.0 µg/kg OC		5,333.33 µg/kg lipid					[14]	F; %lipid = not reported; %sed OC = 1.0

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Wildlife									
Bucephala clangula, Goldeneye	0.012 mg/kg (n = 1)	water = 0.39 ng/L (n = 1)	0.040 mg/kg (whole body) (n = 3)					[15]	F; lower Detroit River; value is mean ± SD
Aythya affinis, Lesser scaup	0.012 mg/kg (n = 1)	surface water 0.39 ng/L (n = 1)	0.025 mg/kg (whole body) (n = 7)					[15]	F; lower Detroit River; value is mean ± SD
Aythya marila, Greater scaup	0.012 mg/kg (n = 1)	surface water 0.39 ng/L (n = 1)	0.040 ± 0.0094 mg/kg (whole body) (n = 3)					[15]	F; lower Detroit River; value is mean ± SD
Falco peregrinus, Peregrine falcon (eggs)			22 ng/g (eggs) (n = 6)	11.4% eggshell thinning				[17]	F; Kola Penninsula, Russia; n = number of clutches sampled
Larus californicus, California gull			440 mg/kg (brain)[4]	Mortality, NA				[18]	L
			183 mg/kg (breast)[4]	Mortality, NA				[18]	L
			3200 mg/kg (liver)[4]	Mortality, NA				[18]	L

Summary of Biological Effects Tissue Concentrations for p,p′-DDT

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Pelecanus occidentalis, Brown pelican			4.55 mg/kg (brain)[4]	Mortality, NA				[18]	L
			66 mg/kg (breast)[4]	Mortality, NA				[18]	L
			7.8 mg/kg (liver)[4]	Mortality, NA				[18]	L
Phalacrocorax penicillatus, Brandts cormorant			230 mg/kg (brain)[4]	Mortality, NA				[18]	L
			500 mg/kg (breast)[4]	Mortality, NA				[18]	L
			840 mg/kg (liver)[4]	Mortality, NA				[18]	L
			810 mg/kg (Liver)[4]	Mortality, NA				[18]	L
Phoca siberica, Baikal seal		particulate: 5.1pg/L ± 2.3 n = 1 dissolved: 50 pg/L ± 23 n = 1	17-21 mg/kg[5] lipid (blubber) n = 1					[16]	F; Lake Baikal, Siberia

[1] Concentration units based on wet weight unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

[5] Not clear from reference if concentration is based on wet or dry weight.

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Chemical Category: PESTICIDE (ORGANOPHOSPHATE)

Chemical Name (Common Synonyms): DIAZINON **CASRN:** 333-41-5

Chemical Characteristics

Solubility in Water: 0.004% at 20°C [1]

Half-Life: No data [2]

Log K_{ow}: 3.70 [3]

Log K_{oc}: 3.64 L/kg organic carbon

Human Health

Oral RfD: 9 x 10^{-4} mg/kg/day [4]

Confidence: —

Critical Effect: Decreased cholinesterase activity

Oral Slope Factor: No data [4,5]

Carcinogenic Classification: No data [4,5]

Wildlife

Partitioning Factors: Partitioning factors for diazinon in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for diazinon in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Partitioning factors for diazinon in aquatic organisms were not found in the literature. Log BCFs ranged from 0.69 to 1.23 (invertebrates) and from 1.59 to 2.90 (fishes).

Food Chain Multipliers: Food chain multipliers for diazinon in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

Diazinon is relatively toxic to aquatic organisms. The acute toxicity for aquatic invertebrates ranged from 0.9 µg/L (48-h LC50) for *Daphnia pulex* [6] to 200µg/L (96-h LC50) for *Gammarus lacustris* [7], while chronic toxicity ranged from 0.27 µg/L (30-d LC50) for *Gammarus pseudolimneaus* to 4.6 µg/L (30-d LC50) for *Acroneuria lycorias* [8]. The maximum acceptable concentration (MATC) for diazinon based on the exposure with sheepshead minnows, was 0.47 µg/L [5], and 3.2 µg/L based on the exposure with fathead minnows [9].

The mode of toxic action of organophosphorus compounds is related to the inhibition of acetylcholinesterase in tissue of animals [10]. A representative of organophosphorus insecticides, diazinon shows species-selective toxicity in fish [11]. For example, diazinon was about 10 times more toxic to the guppy than to the zebra fish [12] and 22 times more potent to loach than killifish [10]. Both the guppy and zebra fish metabolized diazinon to 2-isopropyl-6-methyl-4-pyrimidinol (pyrimidinol). The species-specific oxidative transformation of diazinon or inhibition of acetylcholinesterase are responsible for the differences in diazinon toxicity. During the exposure of pretreated fish (guppies and zebra fish) to diazinon [13], the tissue concentration of pyrimidinol initially increased, then declined to very low levels. Keizer et al. [13] hypothesized that the toxicity of diazinon to guppy is due to its metabolism to a highly toxic metabolite, e.g., diazoxon whereas toxicity to zebra fish is related to bioaccumulation of the parent compound. Fish reached an apparent steady state after 48 hours [12] or 96 hours [14].

Diazinon was most rapidly excreted from the gallbladder followed by liver, muscle, and kidney [11]. The slow excretion rate from kidney was probably because diazinon was transported from all parts of the fish to the kidney before excretion [15]. The log BCFs for eels exposed to 56 µg/L of diazinon were 2.90 in liver, 3.20 in muscle, and 3.36 in gill tissue [16]. Diazinon elimination from the selected tissues was rapid; it was not detected in any tissue after 24-hour exposure in clean water [16]. The results of the study by Kanazawa [17] showed that the concentration of diazinon in tissue of the freshwater fish reached a maximum after 4 days and then decreased gradually. The uptake of diazinon by killifish was not influenced if the fish were exposed to the individual pesticide, or to a pesticide mixture [18].

Diazinon was identified as a major toxicant in municipal effluents [19], indicating persistence of this pesticide in the environment. According to Lee et al. [20], the toxicity of diazinon can be induced by dissolved organic materials.

Summary of Biological Effects Tissue Concentrations for Diazinon

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Invertebrates									
Cipangopoludina malleata, Pond snail		10 µg/L			0.77			[21]	L
Procambarus clarkii, Crayfish		10 µg/L			0.69			[21]	L
Indoplanorbis exustus, Red snail		10 µg/L			1.23			[21]	L
Fishes									
Pseudorasbora parva, Topmouth gudgeon		50 µg/L	11.3 ng/g		2.32			[22]	L
Anguilla anguilla, Eel		10 µg/L	80 ng/g (liver)		2.90			[16]	L
Anguilla anguilla, Eel		10 µg/L	160 ng/g (muscle)		2.90			[16]	L
Gnathopogon caerulescens, Willow shiner					2.39			[23]	F

Summary of Biological Effects Tissue Concentrations for Diazinon

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Pseudorasbora parva, Topmouth gudgeon					2.18			[23]	F
Pseudorasbora parva, Motsugo		0.7 mg/kg	211 mg/kg (4-day) 17 mg/kg (30 day)	Bleeding, abnormal swimming	1.81			[17]	L
Brachydanio rerio, Zebra fish	Ingestion		1,550 mg/kg (whole body)[4]	Mortality, ED100				[13]	L; Lethal body burden
Zacco slatypus, Pale chub					2.18			[23]	F
Plecoglossus altivelis, Ayu sweetfish					1.79			[23]	F
Cyprinodon variegatus, Sheepshead minnow		1.8 µg/L	0.26 mg/kg in 4d, 0.11 mg/kg in 7d, 0.31 mg/kg in 14d		2.17			[14]	L
		3.5 µg/L	0.38 mg/kg in 4d, 0.21 mg/kg in 7d, 0.49 mg/kg in 14d		2.17			[14]	L
		6.5 µg/L	1.3 mg/kg in 4d, 0.5 mg/kg in 7d, 1.4 mg/kg in 14d		2.33			[14]	L
Cyprinodon variegatus, Sheepshead minnow			0.3 mg/kg (whole body)[4]	Morphology, LOED				[14]	L; body darkened, lateral curvature of body

Summary of Biological Effects Tissue Concentrations for Diazinon

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			1.4 mg/kg (whole body)[4]	Morphology, not applicable				[14]	L; body darkened, lateral curvature of body
			0.5 mg/kg (whole body)[4]	Morphology, not applicable				[14]	L; body darkened, lateral curvature of body
			0.05 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; no effect on morphology or appearance
			1.4 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; no effect on mortality
			0.5 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; no effect on mortality
			0.3 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; no effect on mortality
			0.05 mg/kg (whole body)[4]	Mortality, NOED				[14]	L; no effect on mortality
			0.05 mg/kg (whole body)[4]	Physiological, LOED				[14]	L; inhibition of acetylcholinesterase activity
			1.4 mg/kg (whole body)[4]	Physiological, NA				[14]	L; 71% inhibition of acetylcholinesterase activity
			0.5 mg/kg (whole body)[4]	Physiological, NA				[14]	L; inhibition of acetylcholinesterase activity
			0.3 mg/kg (whole body)[4]	Physiological, NA				[14]	L; inhibition of acetylcholinesterase activity
			1.4 mg/kg (whole body)[4]	Reproduction, ED50				[14]	L; 45-55% reduction in average number of eggs produced

Summary of Biological Effects Tissue Concentrations for Diazinon

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
			0.5 mg/kg (whole body)[4]	Reproduction, ED50				[14]	L; 45-55% reduction in average number of eggs produced
			0.3 mg/kg (whole body)[4]	Reproduction, ED50				[14]	L; 45-55% reduction in average number of eggs produced
			0.05 mg/kg (whole body)[4]	Reproduction, LOED				[14]	L; statistically significant reduction in number of eggs produced
Poecilia reticulata, Guppy		0.8 mg/L	25.8 µg/g in 24h, 90.3 µg/g in 48h, 167.7 µg/g in 96h, 109 mg/kg (whole body)[4]	Mortality, ED100				[13]	L; lethal body burden
Poecilia reticulata, Guppy			2,430 mg/kg (whole body)[4]	Mortality, ED100				[24]	L; lifestage: 2-3 months
			2,430 mg/kg (whole body)[4]	Mortality, ED100				[24]	L; lifestage: 2-3 months

[1] Concentration units based on wet weight unless otherwise noted.

[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.

[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

[4] This entry was excerpted directly from the Environmental Residue-Effects Database (ERED, www.wes.army.mil/el/ered, U.S. Army Corps of Engineers and U.S. Environmental Protection Agency). The original publication was not reviewed, and the reader is strongly urged to consult the publication to confirm the information presented here.

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Chemical Category: PESTICIDE (ORGANOCHLORINE)

Chemical Name (Common Synonyms): DICOFOL **CASRN:** 115-32-2

Chemical Characteristics

Solubility in Water: 1.2 mg/L at 20° C (99% purity) [1]

Half-Life: No data [2]

Log K_{ow}: No data [3]

Log K_{oc}: —

Human Health

Oral RfD: 1 x 10^{-3} mg/kg/day [4]

Confidence: —

Critical Effect: Increase in liver to body weight ratios in rats

Oral Slope Factor: No data [5]

Carcinogenic Classification: C [6]

Wildlife

Partitioning Factors: Partitioning factors for dicofol in wildlife were not found in the literature.

Food Chain Multipliers: Food chain multipliers for dicofol in wildlife were not found in the literature.

Aquatic Organisms

Partitioning Factors: Log BCFs ranging from 4.02-4.16 were reported in a study exposing fathead minnows to dicofol [10].

Food Chain Multipliers: Food chain multipliers for dicofol in aquatic organisms were not found in the literature.

Toxicity/Bioaccumulation Assessment Profile

Dicofol is an organochlorine compound used as a miticide. The principal commercial dicofol product, Kelthane, is made from DDT [7]. Clark et al. [7] reported reduction in eggshell weight and thickness of American kestrels due to dicofol. They also observed that 10 µg/g of dicofol reduced hatchability of eggs. They suggested that dicofol concentrations above 3 µg/g in food may affect bird reproduction. The 48-h and 100-h LC50s for grass shrimp (*Crangon franciscorum*) exposed to dicofol (Kelthane) were 590 and 100 µg/L, respectively [8].

The major metabolite of dicofol is 1,1-bis(4-chlorophenol)2,2dichloroethanol (pp-DCD) [9]. Because dicofol is more lipophilic than its metabolites, it was abundant in every tissue except for liver and brain. The dicofol metabolites are less toxic than dicofol and they have less impact on the formation of normal eggshells by doves [9]. The bioconcentration of dicofol in fathead minnows was reduced by 35 percent by clay particles (65 mg/L) indicating that more than 30 percent of the dicofol sorbed onto clay and was biologically unavailable to the fish [10]. Bioconcentration factors at the two dicofol concentrations were not significantly different and steady-state concentrations occured with 40 to 60 days of exposure at 10,500 to 13,900 times water levels.

Summary of Biological Effects Tissue Concentrations for Dicofol

Species:	Concentration, Units in[1]:			Toxicity:	Ability to Accumulate[2]:			Source:	
Taxa	Sediment	Water	Tissue (Sample Type)	Effects	Log BCF	Log BAF	BSAF	Reference	Comments[3]
Fishes									
Pimephales promelas, Fathead minnow		12.38 µg/L			4.02-4.16			[10]	L
		1.15 µg/L			4.12-4.14			[10]	L
Wildlife									
Streptopelia risoria, Ring neck dove	32 mg/kg (diet)		116.5µg/g in fat 1.07µg/g in liver 4.55µg/g in heart 0.37µg/g in brain					[9]	L

[1] Concentration units based on wet weight unless otherwise noted.
[2] BCF = bioconcentration factor, BAF = bioaccumulation factor, BSAF = biota-sediment accumulation factor.
[3] L = laboratory study, spiked sediment, single chemical; F = field study, multiple chemical exposure; other unusual study conditions or observations noted.

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